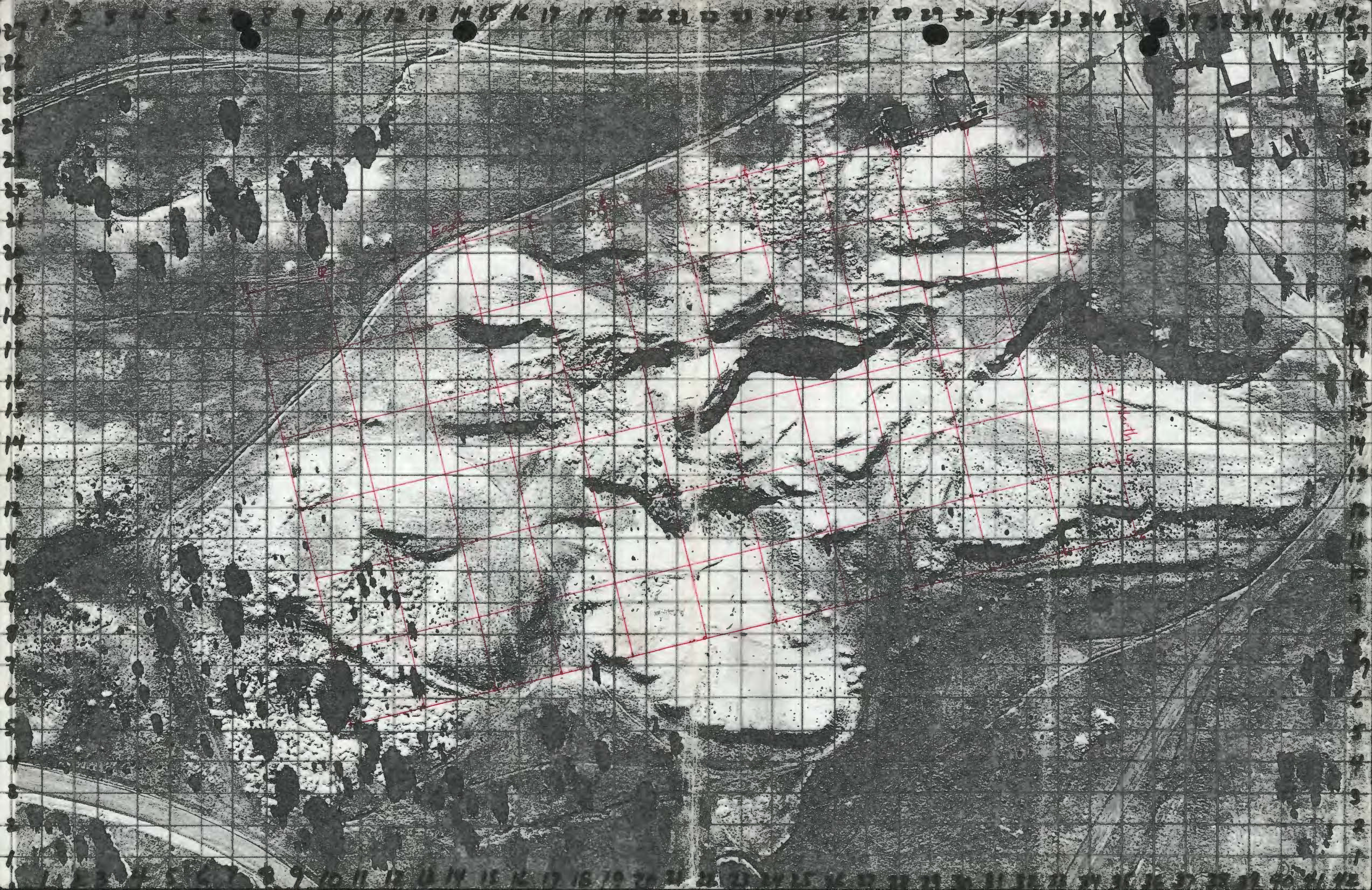
SAMPLING / SURVEYS

1990-1992

UNSCANNABLE MEDIA

To use the unscannable media document # 2334379
contact the Region 9 Regional Records Center – Superfund Division



Post-Remediation Grid
Grid Point Distance = 100 ft.

Reference Grid.
(Same Scale as Maps
of AB, KM and PA+SE)
1 cm ≈ 43 ft

DESPOST.WK1

Desiderio Site
Post-Remediation Survey,
September, 1991

24.7	32.1	11	N0	E0
24.2	29.9	39	N0	E1
23.6	27.6	12	N0	E2
23.1	25.4	11	N0	E3
22.5	23.1	11	N0	E4
22.0	20.9	14	N0	E5
21.4	18.6	14	N0	E6
20.9	16.4	12	N0	E7
20.3	14.1	13	N0	E8
19.8	11.9	13	N0	E9
19.2	9.6	13	N0	E10
18.7	7.4	15	N0	E11
22.4	32.6	17	N1	E0
21.9	30.4	13	N1	E1
21.3	28.1	14	N1	E2
20.8	25.9	12	N1	E3
20.3	23.7	12	N1	E4
19.7	21.4	15	N1	E5
19.2	19.2	12	N1	E6
18.6	16.9	12	N1	E7
18.1	14.7	14	N1	E8
17.5	12.4	19	N1	E9
17.0	10.2	40	N1	E10
16.4	7.9	22	N1	E11
20.2	33.2	12	N2	E0
19.6	30.9	11	N2	E1
19.1	28.7	13	N2	E2
18.5	26.4	17	N2	E3
18.0	24.2	13	N2	E4
17.4	21.9	12	N2	E5
16.9	19.7	11	N2	E6
16.3	17.4	12	N2	E7
15.8	15.2	14	N2	E8
15.3	13.0	16	N2	E9
14.7	10.7	18	N2	E10
14.2	8.5	28	N2	E11
17.9	33.7	15	N3	E0
17.4	31.5	22	N3	E1
16.8	29.2	12	N3	E2
16.3	27.0	11	N3	E3
15.7	24.7	15	N3	E4
15.2	22.5	11	N3	E5
14.6	20.2	12	N3	E6
14.1	18.0	10	N3	E7
13.5	15.7	50	N3	E8
13.0	13.5	18	N3	E9
12.4	11.2	14	N3	E10
11.9	9.0	25	N3	E11
15.6	34.2	12	N4	E0
15.1	32.0	13	N4	E1
14.5	29.7	13	N4	E2
14.0	27.5	12	N4	E3
13.5	25.3	17	N4	E4
12.9	23.0	12	N4	E5
12.4	20.8	12	N4	E6
11.8	18.5	11	N4	E7

11.3	16.3	20	N4	E8
10.7	14.0	30	N4	E9
10.2	11.8	30	N4	E10
9.6	9.5	14	N4	E11
13.4	34.8	12	N5	E0
12.8	32.5	15	N5	E1
12.3	30.3	13	N5	E2
11.7	28.0	14	N5	E3
11.2	25.8	11	N5	E4
10.6	23.5	12	N5	E5
10.1	21.3	11	N5	E6
9.5	19.0	14	N5	E7
9.0	16.8	18	N5	E8
8.5	14.6	14	N5	E9
7.9	12.3	18	N5	E10
7.4	10.1	13	N5	E11
11.1	35.3	15	N6	E0
10.6	33.1	25	N6	E1
10.0	30.8	32	N6	E2
9.5	28.6	15	N6	E3
8.9	26.3	11	N6	E4
8.4	24.1	12	N6	E5
7.8	21.8	10	N6	E6
S	W	Waist Gamma (uR/hr)		

Avg Gamma 15.86 uR/hr

Desiderio Site
Post-Remediation Survey, September, 1991

* The first three columns, (A,B,C) are exactly scaled to the "Pre-Remediation" survey on the Desiderio Site. Therefore, if they are imported into Surfer and treated in exactly the same manner as the "Pre" survey data, the grid and scale of the two plots should be identical, and one could overlay the other for comparison of results.
The next two columns, (D & E), give the coordinates that we assigned during the "Post" survey.

(A1 - A79), (B1 - B79) and (C1 - C79) are the data that should be imported into Surfer.

Desiderio Post-Reme Study, $\mu R/hr$ @Waist-level

	N-0	N-1	N-2	N-3	N-4	N-5	N-6
E-0	11	17	12	15	12	12	15
-1	39	13	11	22	13	15	25
-2	12	14	13	12	13	13	32
-3	11	12	17	11	12	14	15
-4	11	12	13	15	17	11	11
-5	14	15	12	11	12	12	12
-6	14	12	11	12	12	11	10
-7	12	12	12	10	11	14	
-8	13	14	14	50	20	18	
-9	13	19	16	18	30	14	
-10	13	40	18	14	30	18	
-11	15	22	28	25	90 18	13	

W S 8

32.1 24.7 11

2.29545

.54545

W S 8

36.3 11.1 15

+. ~~.29999~~

.53333 ~~1.23636~~

2.26667

7.4 18.7 15

Pg #1 Patrick Stanley   Dissidence Site   Ludlum 19 (Clayton)
SN 36522

µR/HR

✓ 1. 16	* 29 110	57. 80	*85. 240
2 16	30 60	* 58 140	*86 220
✓ 3 20	31 24	*59. 220	*87 150
4 25	✓ 32 24	*60. 190	*88. 150
✓ 5 30	33 24	*61 200	89. 130
✓ 6 60	✓ 34 26	* 62 100	90. 150
7 30	35 24	*63 120	91 150
8 75	✓ 36. 24	*64 100	92 160
✓ 9 90	37 24	* 65 165	93 155
✓ * 10 140	38. 30	*66 210	94 150
✓ 11 80	✓ 39. 32	*67 140	95. 90
✓ 12 30	40 22	* 68 140	*96. 250
✓ 13 70	* 41 100	* 69 150	*97. 440
14 70	✓ * 42. 110	* 70. 110	*98. 800
✓ 15 28	43 22	71. 18	*99. 300
16 80	44 20	*72. 135	*100. 400
17 75	45 28	73. 18	*101 300
* 18 110	✓ 46 40	74. 18	102 50
✓ *19 120	✓ * 47. 240	75. 34	*103 220
✓ *20 110	✓ 48. 60.	76. 70	104 40
21 24	49 60	77 20.	*105 220
22 80	*50 130	78. 32	*106 400 107 26
23 80	✓ *51 150	*79 130	*108 210
24 90	*52 110	* 80 110	*109 200
25 50	53. 26	*81 100	* 110. 130
✓ 26 15	54 20	*82 100	* 111. 150
✓ 27 80	55 22	* 83 230	112 15
✓* 28 120	56. 20	* 84 120	113 18

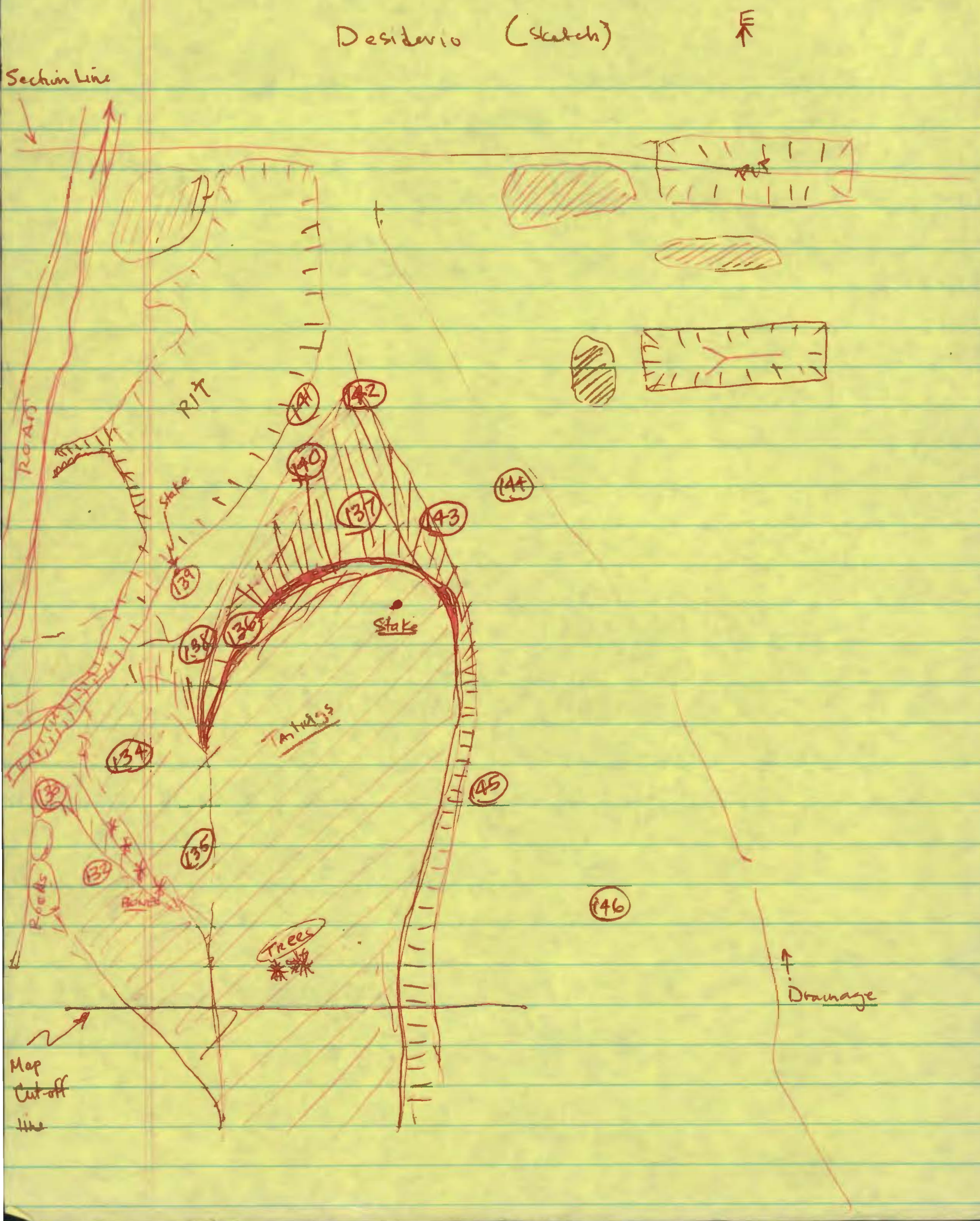
Pg # 2 . . .

Desiderio [redacted] - Ludlum 19 (Wa[redacted]n) 1/.7

S# 36522

	μR/hr		
114	17	142.	220
115	70	143.	110
* 116	110	144.	18
117	36	145.	16
* 118	150	146.	15
119	46	147.	
120	22	148	
121	90	149.	
122	140	150	
123	80		
124	40		
125	60		
126	85		
127	45		
128	26		
129	16		
130	21		
131	16		
132	32		
133	20		
134	120		
135	65		
136	120		
137	65		
138	120		
139	17		
140	28		
141	16		

Desiderio (Sketch)



112
105
104
103
99
98
102
Rattlesnake

Art

White $\frac{1}{.7}$

1 15/15
2 20/20
3 30/30
4 30/40
5 15/15
6 30/30
7 20/20
8 50/50
9 100/260
10 180/260
11 50/50
12 70/130
13 120/230
14 50/50
15 24/24
16 30/18
17 20/20
18 20/22
19 14/14
20 20/18
21 20/24
21 20/20
23 18/18
24 32/28
25 30/24
26 50/50
27 38/40
28 48/32

29 = 60/80
30 = 150/320
31 = 50/50
32 = 30/24
33 = 50/50
34 = 100/100
35 = 32/28
36 = 150/300
37 = 100/130
38 = 130/150
39 = 140/120
40 = 60/50
41 = 150/120
42 = 320/2000
43 = 30/30
44 = 70/50
45 = 24/20
46 = 50/60
47 = 40/36
48 = 26/28
49 = 30/30
50 = 40/36
51 = 32/32
52 = 44/40
53 = 180/600
54 = 50/50
55 = 24/20
56 = 24/22

57 = 25/22
58 = 25/22
59 = 15/15
60 = 16/16
61 = 18/18
62 = 22/20
63 = 30/20
64 = 20/20
65 = 24/22
66 = 30/22
67 = 26/20
68 = 30/25
69 = 25/22
70 = 100/200
71 = 26/28
72 = 46/55
73 = 130/260
74 = 40/25
75 = 100/70
76 = 180/180
77 = 200/360
78 = 240/320
79 = 24/24
80 = 170/200
81 = 300/380
82 = 160/110
83 = 36/24
84 = 25/24

85 = 60/140
86 = 34/27
87 = 300/2400
88 = 70/225
89 = 50/60
90 = 40/34
91

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8:15 Crews depart of Lagunas for Quad 18 - start photodocumentation Quad 24

11 East from 2 S W16	Roll 2 1 E of S 22.5 W9
12 E of S4 W16	2. E of S21 W5
13 E of S6 W16	3. Bank + HS at S19 W6
14 E of S8 W16	4 E of S18 W5
15 E of S10 W16	5 E of S17 W5
16 E of S12 W16 (fee area upper road)	6 E of S16 W6
17 N of S9 W14	7-15 Panorama W to E of S16 W6
18 E of S0 W12	16 Wide angle N of S16 W6
19 S of S4 W12	17 " Scoop S of S17 W3
20 E of S7 W12	18 Along vent line S of S19 W0
21 E of S10 W12	19-22 Panorama S to N of S19 W0
2 E of S12 W12	along line 23 W of S14 W0
3 E of S14 W12	24 W of S10 W0
4 E of S16 W12	25 W of S4 W0

Patrick + Stanley (Navajo Superfund) arrive - head off to Quad 18 and Desiderio

Finish taking Quad 24 photodocumentation proceed to Desiderio w/ Jerry G.

Arrive at Desiderio - Discuss w/ Rob B. plans for Desiderio rad survey - to split up into three teams - do random spot checks and flag hot ies

Waist / Ground

Split into 3 groups - Patrick / Stanley ③; Art, ② Glen / Ken ① Rad readings:

0 | 50	7. 200 | 500	13. 500 | 800	19. 40 / 48	25. 100 | 110	31. 250 | 500
0 | 30	8. 200 | 400	14. 10-50	20. 110 | 250	26 80 | 80	32. 400 | 3000
/ 10	9. 200 | 380	15. 500 | 500	21. 180 | 400	27. 130 | 130	33. 300 | 300
	10. 200 | 400	16. 170 | 200	22.* 130 | 110	28 250 | 800	34. 50 | 50
/ 200	11. 300 | 500	17. 250 | 600	23. 310 | 380	29. 110 | 110	35 30 | 30
0	12. 300 | 500	18. 310 | 1000	24. 100 | 130	30. 300 | 1500	36. 25 | 25

* Correct!

11:30 11:40 Water break - Finished Rt Quadrant, on to N end of next Quad 75

Ken

37. 28 | 28	59. Wall 100-300	81 35/35
38 20 | 20	60. Wall 400	82 35/35
39 30 | 30	61. Floor 100-200	83 50/50
40 32 | 32	62. Wall 300-400	84 50/400
41 120 | 300	63 35 | 35	85 35/35
42 50 | 50	64. 50 | 50	86 40 | 75
43 50 | 50	65. 100 | 100	87 50/50
44 100 | 800	66. 50 | 50	88 65 | 750
45 50 | 50	67 75 | 75	89 30 | 30
46 35 | 35	68 135 | 140	90 75 | 300
47 35 | 35	69 65 / 65	91 45/45
48 30 | 30	70 600 | 2000	92 50 | 50
49 30 | 30	71 24 | 24	93 75/75
50 38 | 38	72 35 | 35	94 45/45
51 30 | 30	73 50 | 70	95 35/35
52 50 | 50	74 35 | 35	96 50 | 50
53 80 | 80	75 35 | 35	97 50/50
54 110 | 170	76 28 | 28	98 130 | 1000
55 100 | 100	77 25 | 25	99 35/35
56 150 | 150	78 60 | 500	
57 100 | 100	79 70 | 70	
58 110 | 110	80 60 | 100	

12:30 Break from rad survey; return to vehicles, disrobe and head to Brown-Vandever

1:15 Get to Conoco for lunch make phone calls to Office - to Art Ball - Flight out ~~2:00~~ Wednesday morn. - informed Gary B. of plans


61
24
40

SECTION 18 GRID R[illegible]P READINGS

~~8/16~~ 8/17/91 9:58 AM

	WG E0		W1 E-1		W2 E-2		E-3 W3		E-4 W4	
			WAIST	GRND	W	GRD	WAIST	GND	WAIST	GND
N0	75	60	32	37	30	32	120	120	33	26
N1	125	120	40	42	33	32	33	32	37	27
N2	100	145	60	55	38	35	28	28	25	25
N3	130	140	85	75	80	115	60	60	25	25
N4	65	50	110	125	95	100	65	75	60	75
N5	42	42	85	75	65	55	35	38	38	29
N6	75	70	70	105	75	65	24	25	22	21
N7	850	800	550	600	85	85	26	26	23	23
N8	170	125	350	380	80	75	25	26	22	21
N9	36	38	38	39	27	26	24	25	21	21
N10	34	33	28	28	25	23	25	24	19	19
N11	37	36	25	25	20	20	20	20	19	19
N12	29	27	22	23	20	20	19	19	19	18
N13	24	22	20	19	19	18	19	19	18	17

W5

N5 20 21

N	E1 W/G	E2	E3	E4	E5
0	—	—	—	—	—
1	40/40	30/26	—	—	—
2	75/60	42/44	30/27	24/24	—
3	70/60	100/110	110/85	38/28	27/25
4	105/105	110/120	280/350	300/370	32/32
5	55/55	70/70	420/600	370/500	—
6	115/120	100/115	250/240	280/300	380/500
7	380/450	90/95	270/290	250/330	240/250 ~~60/50~~
8	80/65	100/115	86/80	130/190	~~40/38~~ ~~40/38~~ 60/50
9	70/90	240/300	160/220	200/200	~~40/38~~ ~~32/32~~ 40/38
10	65/50	280/360	130/130	160/170	~~38/30~~ 32/32
11	150/160	36/30	210/250	75/50	—
12	26/25	50/50	24/24	25/24	—
13	24/22	24/20	18/16	22/20	—

E6 N6] — 40/32

E6 N7] — 35/30

SECTION 24 RAD READINGS

in MR/HR

W	S-1 W	S-1 G	S-3 W	S-3 G	S-5 W	S-5 G	S-7 W	S-7 G	S-9 W	S-9 G	S-11 W	S-11 G	S- W	S- G
0	23	24	130	125	24	25	36	36	32	41	45	40		
1	20	22	44	46	27	27	32	33	35	34	60	50		
2	22	22	39	38	39	31	31	31	34	34	45	40		
3	24	25	28	27	35	36	30	29	32	31	65	50		
4	65	35	26	26	41	39	39	37	31	30	90	90		
5	100	85	24	24	33	30	50	40	33	32	60	55		
6	50	55	25	24	26	26	60	60	40	38	60	55		
7	25	22	26	25	29	28	50	50	70	60	125	155		
8	27	32	25	24	38	40	80	100	125	165	65	50		
9	29	29	27	26	41	36	65	75	100	90	90	80		
10	24	23	35	30	65	60	40	41	50	39	130	130		
11	24	25	39	40	80	130	35	34	65	60	65	65		
12	65	60	90	115	80	75	40	35	95	120	33	33		
13	31	29	46	44	90	85	55	50	80	85	29	29		
14	65	65	40	42	135	180	140	210	65	70	230	275		
15	27	26	44	38	90	65	27	28	45	[illegible] PILE 35	22	22		
16	50	60	40	39	50	40	29	28	50	45	20	20		
17	36	40	20	21	27	27	30	30	60	60	20	19		
18	23	24	16	17	24	23	25	26	55	55	18	19		

ORPPIE METER

1:45 - 2:30

PARTLY CLOUDY

8/15/91

Sam Dean

START

4:15 PM

BATTERY CHECK

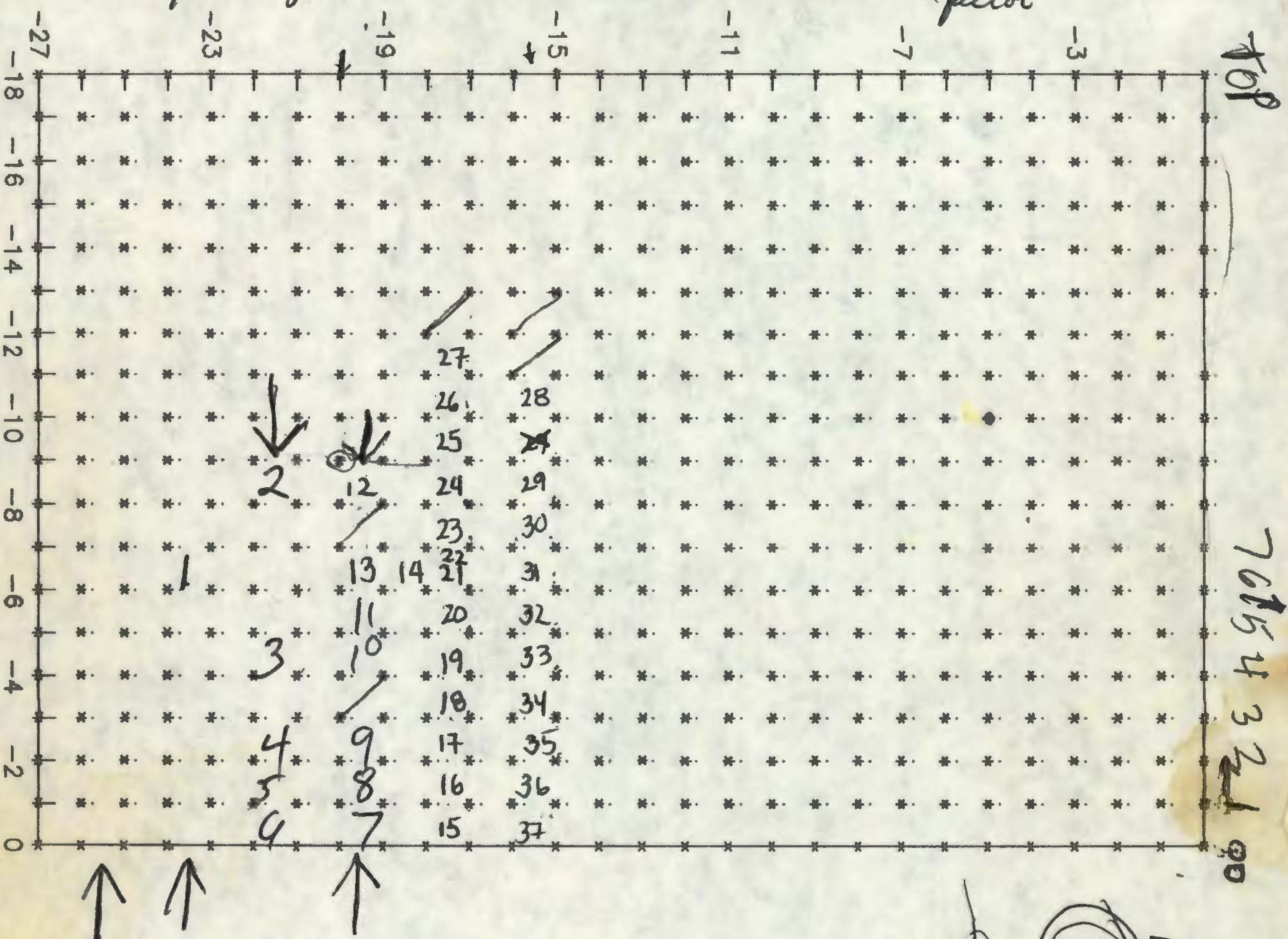
OK

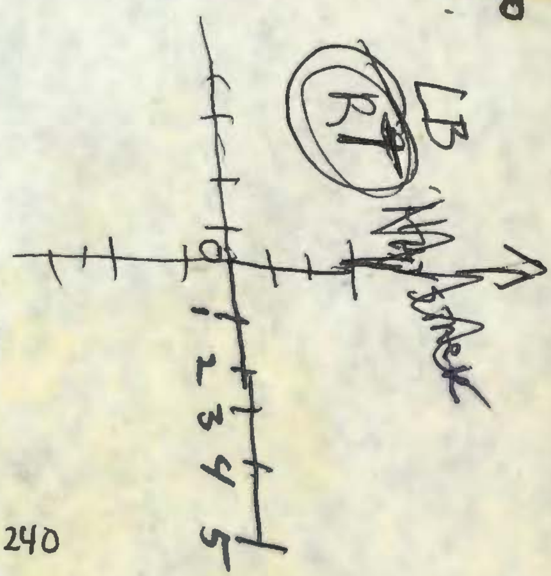
6:10 PM

STOP

Waylon Raw (1.25X)

Art/Cindy Instrument: WAYLON 36522 Conversion factor 1.25



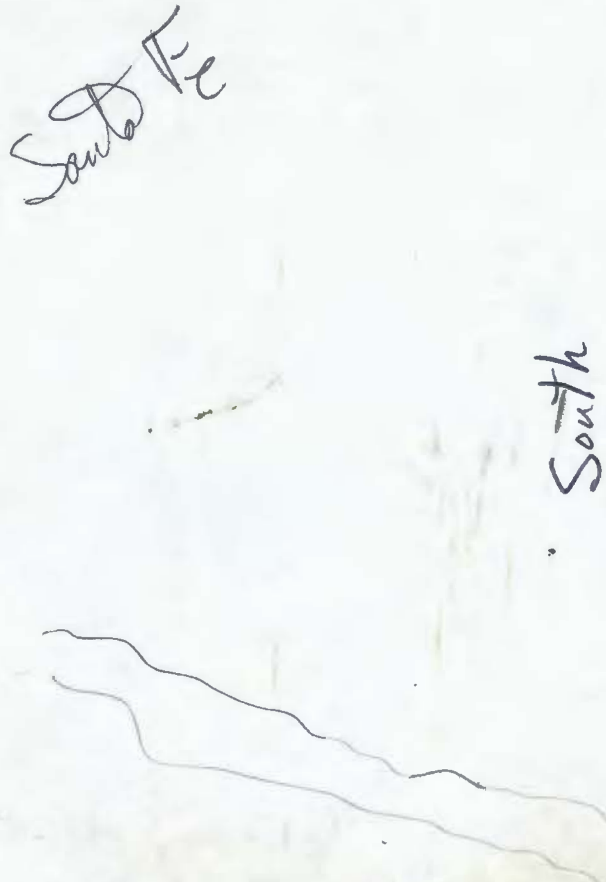


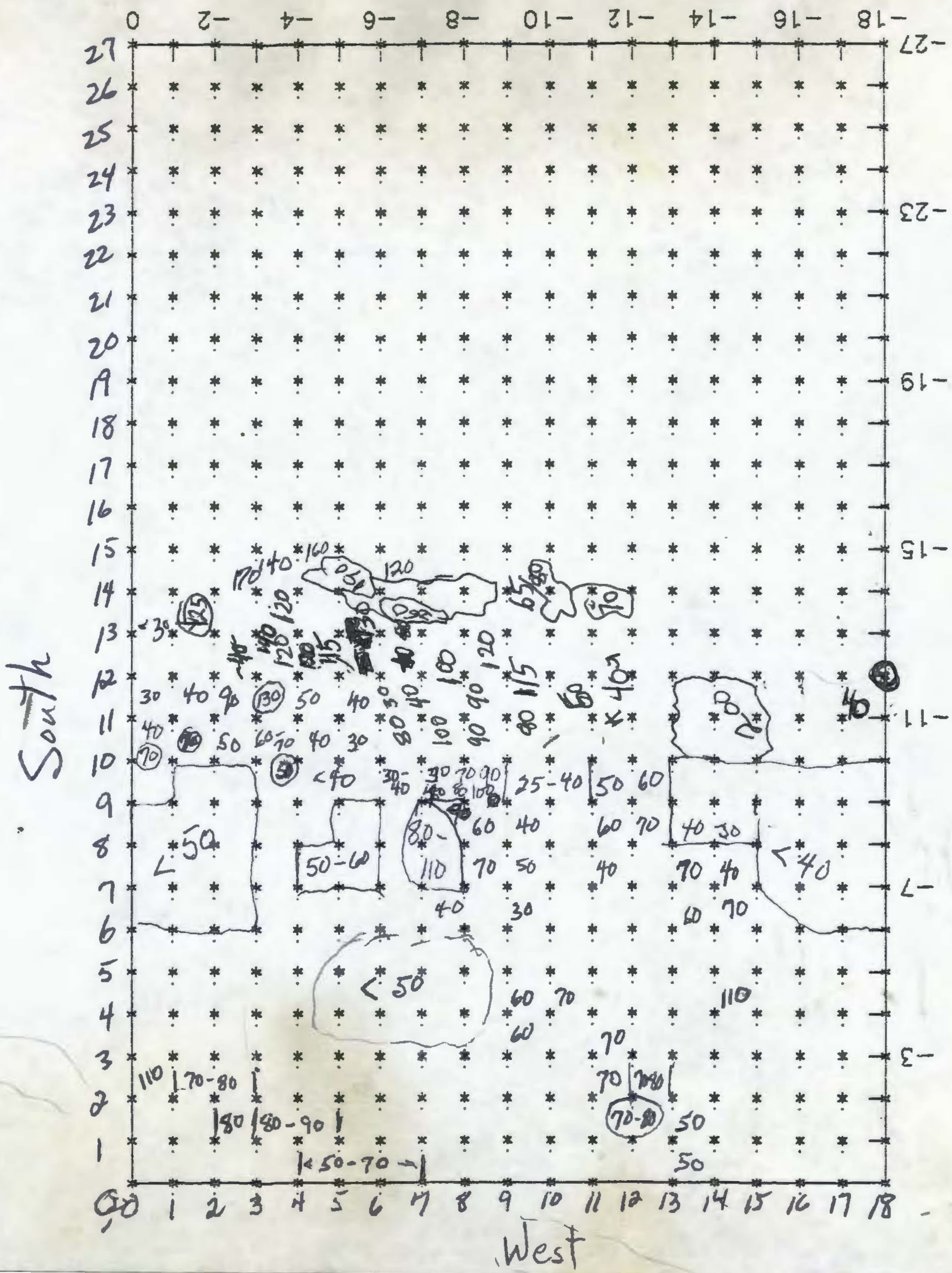
1=360
2=180
3=130
4=140
5=1000
6=420
7=350
8=600
9=260
10=140

11=950
12=200
13=250
14=1000
15=500
16=500
17=240
18=1000
19=130
20=800
21=250
22=500
23=200

24=220
25=200
26=200
27=350
28=360
29=180
30=170
31=600
32=~~300~~ 240
33=200
34=220
35=340
36=360
37=1200

Hot Spot Survey
Quad 24, 8/16/91
G. Gels
using "Willie" #36518
Mdl 19





START

SECTION 24 RAD READINGS FOR GRID.

8/16/81 8:20 Am

W	S-13		S-15		S-17		S-19		S-21		S-23		S-25	
	W	G	W	G	W	G	W	G	W	G	W	G	W	G
0	39	40	75	75	38	39	38	30	70	55	37	34	26	26
1	65	55	55	50	70	110	125	130	80	120	35	34	27	28
2	45	50	65	75	75	80	100	90	110	115	30	29	26	24
3	150	700	85	85	100	115	95	90	70	65	30	30	30	32
4	110	90	165	165	70	35	65	65	44	46	29	28	27	26
5	190	200	160	155	85	85	65	80	65	65	55	50	23	21
6	175	200	145	140	135	150	125	125	90	85	45	38	21	20
7	95	90	84	86	100	85	85	105	48	46	25	135	22	21
8	85	75	47	42	50	50	85	100	60	60	29	31	19	17
9	190	185	46	40	55	55	31	30	27	25	25	24	16	15
10	110	115	38	34	50	50	28	28						
11	30	29	38	48	39	31	25	24						
12	29	29	22	22	23	21	22	23						
13	22	22	20	20	18	18	19	19						
14	20	20	18	18										
15	19	19	18	18										
16														
17														
18														

e

SECTION 24

GRID RAD READINGS 8/16/91

	S-27	
W	W	G
0	20	19
1	21	20
2	22	21
3	25	23
4	22	22
5	23	23
6	21	22
7	20	18
8	33	22
9	15	14

ENDED
10:25 Am

BAT CK OK
ON ORPIE METER

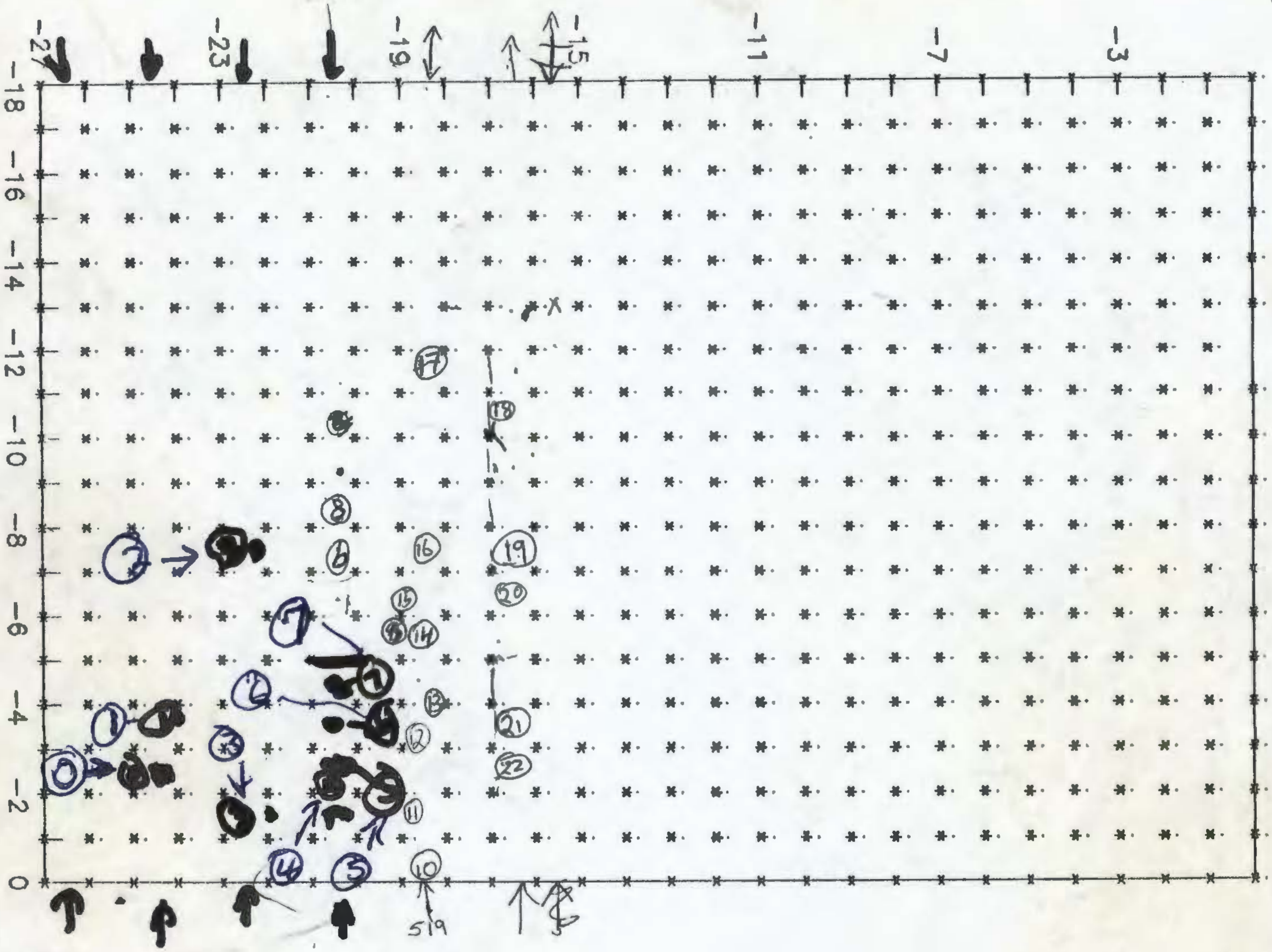
Waylon Raw (1.25 X 8/16/91) ÷ .7 gls 8/17/91

W	S-12 W	S-12 G	S-14 W	S-14 G	S-16 W	S-16 G	S-18 W	S-18 G	S-20 W	S-20 G	S-22 W	S-22 G	S-24 W	S-24 G
0	27	27	70	60	60	60	28	28	70	60	25	22	26	24
1	32	32	32	34	38	36	70	60	90	145	34	28	20	18
2	32	24	70	60	70	80	150	180	90	105	40	70	20	19
3	80	65	70	60	120	185	260	420	60	55	32	36	32	32
4	140	150	120	100	140	160	70	65	70	60	22	20	36	26
5	120	140	220	160	80	65	70	65	60	50	65	110	22	22
6	65	60	190	150	75	80	110	120	14	13	26	24	24	22
7	80	90	120	115	120	140	190	200	80	80	28	26	24	20
8	34	30	42	36	55	38	40	35	38	42	75	65	14	14
9	130	120	100	110	28	25	26	22	20	20	20	18	15	14
10	150	170	32	36	28	28	28	34	[illegible]					
11	60	40	120	150	32	24	80	70						
12	22	20	20	20	20	16	20	16						
13	20	18	16	16	14	14	14	17						
14	18	16	14	14										
15	13	12	14	14										
16	12	12												
17	12	12												
18	10	10												

S-26

	W	G
0	16	16
1	16	16
2	16	16
3	16	16
4	16	16
5	14	14
6	14	14
7	14	12
8	10	10
9	10	10

West ↓	S-0		S-2		S-4		S-6		S-8		S-10	
	W	G	W	G	W	G	W	G	W	G	W	G
0	30	125	115	200*	33	31	36	31	46	55	36	36
1	20	20	46	29	30	26	33	29	30	31	38	36
2	23	23	80	75	29	29	80	90	30	30	35	35
3	19	21	94	81	31	31	46	44	29	29	40	33
4	24	20	31	33	31	35	33	30	29	28	95	75
5	24	48	29	26	35	33	28	28	50	50	36	36
6	28	28	28	28	25	25	31	31	80	80	39	29
7	68	70	81	125	28	28	34	35	90	90	44	46
8	25	25	25	23	30	31	31	31	115	90	90	90
9	23	23	20	20	29	29	30	30	100	165	95	90
10	20	20	23	23	31	31	75	75	35	35	65	50
11	25	28	23	23	54	54	100	140	45	45	75	95
12	41	56	75	94	80	95	95	120	39	38	40	31
13	28	23	40	38	65	65	80	90	150	150	100	115
14	44	55	55	45	155	230	95	95	33	31	40	40
15	33	33	38	38	30	29	90	90	50	56	29	29
16	48	95	28	23	25	25	36	34	25	28	25	23
17	33	35	20	19	18	18	29	28	35	28	48	60
18	20	18	18	26	18	18	20	21	31	38	45	60



0 0 125
1 1 165
2 2 1700 μR
3 3 950
N 4 4 175 μR
5 5 230
6 6 1400
7 7 250

8 - 1000 μR
9 - 210 μR
10 - 430 μR
11 - 250 μR
12 - 2300 μR
13 - 900 μR
14 - 850 μR
15 - 1000 μR
16 - 1200 μR
17 - 210 μR
18 - 300 μR
19 - 175 μR

20 750 μR
21 410 μR
22 240 μR

2:00 Return to site - we confer w/ Rob. B. on Desiderio; generally pleased with characterization to this point - continue on Desiderio to large cut out of of map

3:30 Arrive at Desiderio - visual survey of area off of map - park on dirt road - Same 3 teams: break out areas on map -

4:15 Quit rad survey; head back to truck - Art B. finishes his section, Glenn 4 J. finish deepest cut and slag/tree field; Pat/Stan finish southern portion + 4 piles (east) then east of road to unmapped area; rattlesnake at Stan/Pat #105

4:30 Left Desiderio to Brown/Vandever

4:45 Arrive Brown Vandever site - view Laguna progress on western end

5:20 Leave site w/ Art Ball, Glenn Rogers; left Gerry G. at gate check

~5:50 Arrive back at hotel 800-525-0280 Continental

~~8:00~~ 6:30 Meet at hotel Art B., Glenn R., Jerry G.; R. Bornstein left ahead to site gather radios, etc.

~7:00 Leave McA's

7:35 Arrive on site - proceed to Quad 24 - talk w/ R. Bornstein aka Desiderio - finish up - then photodocumentation

8:00 Leave Brown-Vandever proceed to Desiderio w/ Art Ball, Glenn Rogers - leave Gerry G. behind to monitor access to site, etc.

8:20 Arrive Desiderio - survey (guided) remaining plot

8:45 Rad survey begins Glenn R. down in gully, Art. B. on Top

1 20/20	6 20/20	11 20/80	16 80/400	21 120/150	26 100/150
2 20/20	7 15/15	12 20/22	17 60/180	22 165/200	27 150/150
3 20/20	8 30/50	13 22/24	18 Wall 50-75	23 150/150	28 80/80
4 20/20	9 50/200	14 20/20	19 100/300	24 150/300	29 120/120 W
5 20/20	10 20/20	15 30/70	20 50/50	25 150/180	30 220/800 W

W = Waylon (Art) No W = ORP (Glenn)

31 50/50 W	56 100/200
32 100/210 W	57 100/100 W
33 100/120 W	58 26/26 W
34 150/150 W	59 20/20
35 50/50	60 30/30
36 75/100	61 100/150 W
37 100/120 W	62 150/200 W
38 80/90 W	63 75/75
39 80/500 W	64 50/50
40 300/800	65 70/80
41 100/500	66 50/50
42 500/500 W	67 80/130
43 200/1000 W	68 80/140
44 100/100	69 50-150 wall
45 skipped	70 180/300
46 120/180 W	JK
47 300/1000 W	
48 200/800	
49 50/50 W	
50 50/50	
51 300/1000 W	
52 150/150 W	
53 150/150	
54 100/160 W	
55 130/180 W	

1 pg.

Tuesday

Desiderio [illegible]fe

mR/Hr Waist level

"Willie"

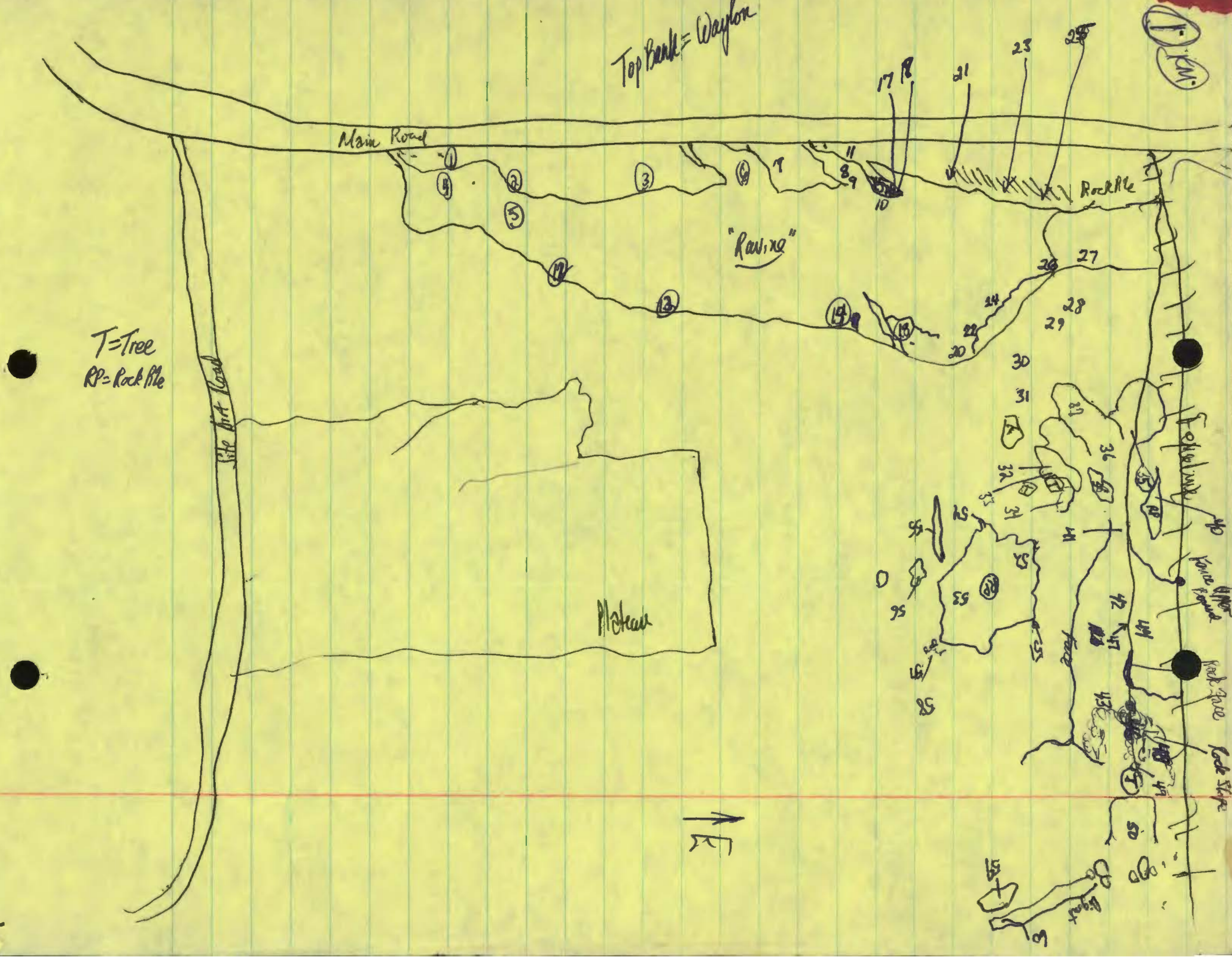
Serial # 36518

Stan/Pat 8/20/91

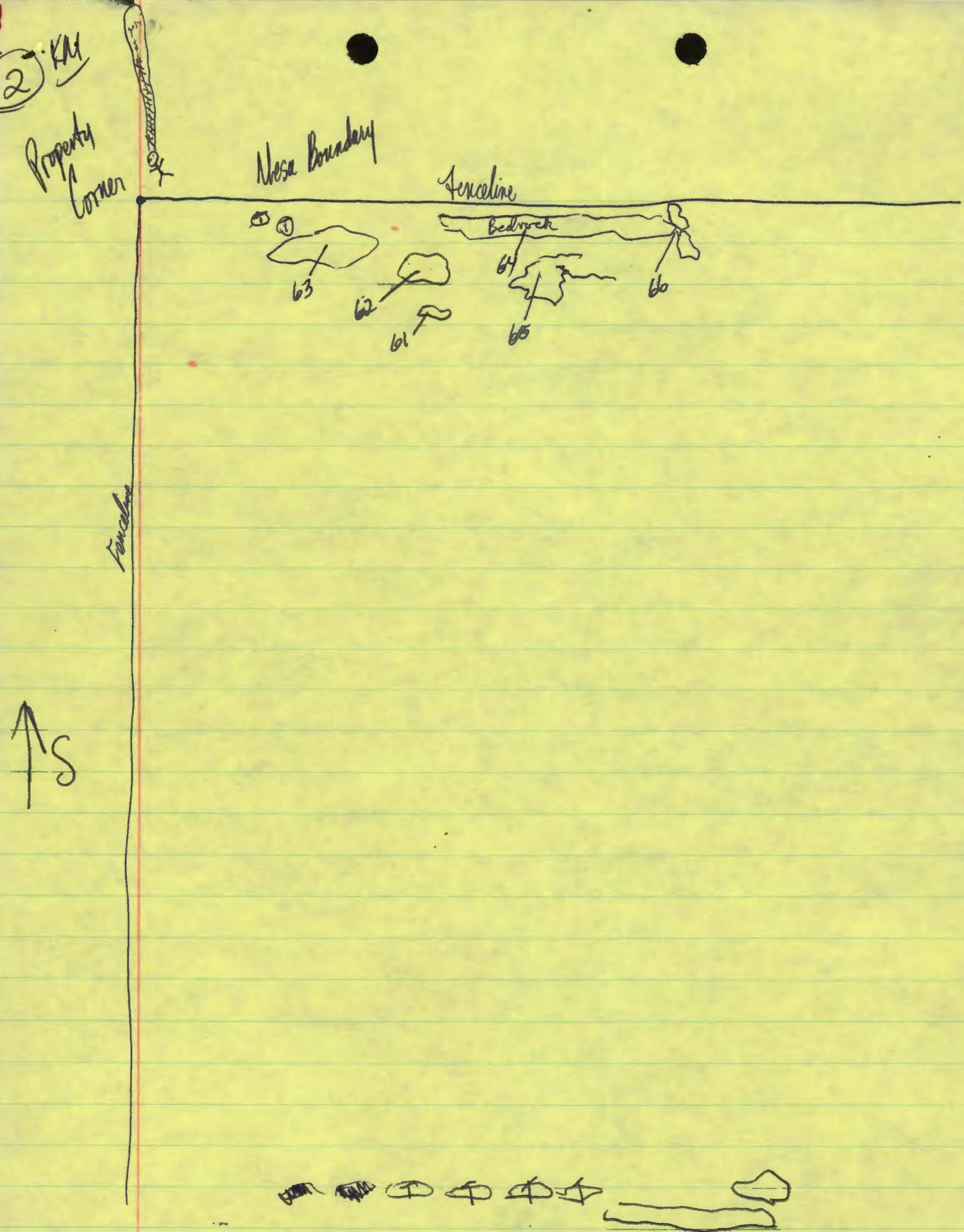
1	34	29.	14	57
2	22	30.	20	58
3	70	31.	14	59
4	20	32.	14	60
5	18	33	14	
6	20	34	13	
7	24	35	14	
* 8	240	36	14	
* 9	400	37	14	
10	41	38	26	
11	42	39	12	
12	30	40,	30	
13	70	41	34	
14	115	42	50	
*15	300	43	30.	
16	34	*44	125	
17	110	45.	60	
18	20	46.	40	
19	32	47	13	
20	16	48		
21	30	49		
22	36	50.		
*23	140	51		
24	20	52		
*25	240	53		
*26	100	54		
27	21	55		
28	22			

Stan/Pat 8/20/91

Stan/Pat 8/20/91


Top Bank = Waylon
Main Road
Rock Pile
"Ravine"
T=Tree
RP= Rock Pile
Plateau
Fenceline
Fence
Rock Face
Rock Slope

② KM


Property Corner
Mesa Boundary
Fenceline
Bedrock
63
62
61
64
65
66
Fenceline
S

8-27-91 Post - Removal Survey, Section 24, Nanabah - Vandever

8/28: Legs S-14 through S-23, dozer covered to bring down to 56 or less.
MWS

NOT DISTURBED

South

27																				
26																				
25																				
24																				
23	28	28	24	22	24	50	36	16	30	10										
22	24	22	20	22	26	24 80 100	50	34	20	14										
21	[illegible]6	26	36	20	36	50	30	24	24	14										
20	80	30	34	22	32	60	30	30	18	16										
19	26	50	30	42	46	44 60	40	50	22	18	14	12								
18	22	32	38	26	48	70 70	60 70	50	24	18	20	18	12							
17	32	30	40	24	36	55 60	50	40	34	24	26	16	16	10						
16	32	26	44	24 70	60 60	50	46	40	24	26	20	14	14	12						
15	55	26	36	23	50 70	65	50	50 60	42	30	28	26	18	14						
14	42	28	44	28	44	30	44	60 60	32	22	16	22	20	16						
13	26	26	24	26	24	44	55	50	36	34	36	20	22	14	14	12				
12	26	22	22	30	32	46	46	36	50	44 33	32	20	18	14						
11	26	24	20	26	32	46	40	40	32	80	36	22	20	18	24	12				
10	[illegible]8	18	20	20	24	38	50	26	28	30	38	32	36	20	18	20	42	32	34	→ 24
9	22	24	20	20	18	20	22	24	32	40	22	~~18~~ 50	26	32	16	18	34	36	40	→ 30
8	28	26	22	18	18	20	30	30	34	24	24	34	44	34	24	20	20	22	14	→
7	23	20	20	20	20	26	40	30	36	24	38	42 55	24	39	27	22	18	24	14	
6	24	20	20	32	24	23	26	30	24	34	42	20 40	34	22	20	20	14	12	14	
5	22	20	20	36	20	22	24	36	46	60	50	22	24	20	18	20	14	12	14	
4	26	24	22	28	25	28	22	18	22	24	41	40	18	18	24	22	16	12	12	
3									24	28	27	20	18	18	30	30	21	14	12	
2									24	30	18	16	16	20	32	70 80	20	18	14	
1										30	20	18	18	15	20	18	27	18	18	
0																				
0,0	00	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

M-82 (10/9/82)

8-17-91
08:00 AM

Ludlum Model 19 μR-Meter Calibration vs. RSS-111 Reuter-Stokes Pressurized Ionization Chamber (PIC)

Readings were taken at 3 different locations within Section 18 (Brown - Vandever) at the same height above ground (~1 meter) using the PIC and 5 different Ludlum model 19 μR instruments.

The instruments were:

Reuter-Stokes	Model RSS-111	S/N	Z5880	(read-out)
			5854	(ion chamber)
Ludlum Mdl 19	EPA (ORP)	S/N	30756	
	EPA (Las Vegas)		53216	
	REAC ("WAYLON")		36522	
	REAC ("WILLIE")		36518	
	Santa Fe		85931	

At Site #1, the PIC reading was obtained by visual observation of the digital meter (310 μR/hr), since at that elevated level the meter was very steady. At the other two sites a total of 20 observations (over 100 seconds) were taken, and the average and std. dev. were recorded for these. The Ludlum instruments were switched to the appropriate scale, and a wait of at least 1 minute for equilibrium preceded each reading.

SITE #1: PIC ⇒ 310 μR/hr.

	Reading	Scale
~~EPA (ORP)~~		
EPA (ORP)	600	0-5000
REAC (Waylon)	405	0-500
	500	0-5000
REAC (WILLIE)	410	0-500
	300	0-5000
EPA (Las V)	580	0-5000
Santa Fe	475	0-500
	500	0-5000

PIC Data: 310 μR/hr (visual)

SITE #2: PIC ⇒ 48.5 μR/hr

Reading	Scale
108	0-250
90	"
75	"
95	"
80	"

PIC Data (μR/hr):

49.8	48.5	48.3
48.2	47.8	48.8
47.4	48.4	47.5
48.3	48.6	48.4
47.5	48.0	50.6
48.0	47.2	49.6
		49.7
		48.9

48.5 ± 0.87

SITE #3: PIC ⇒ 26.5 μR/hr

Reading	Scale
62	0-250
42	0-50
40	0-50
53 ?	0-50
55	0-250
43	0-50

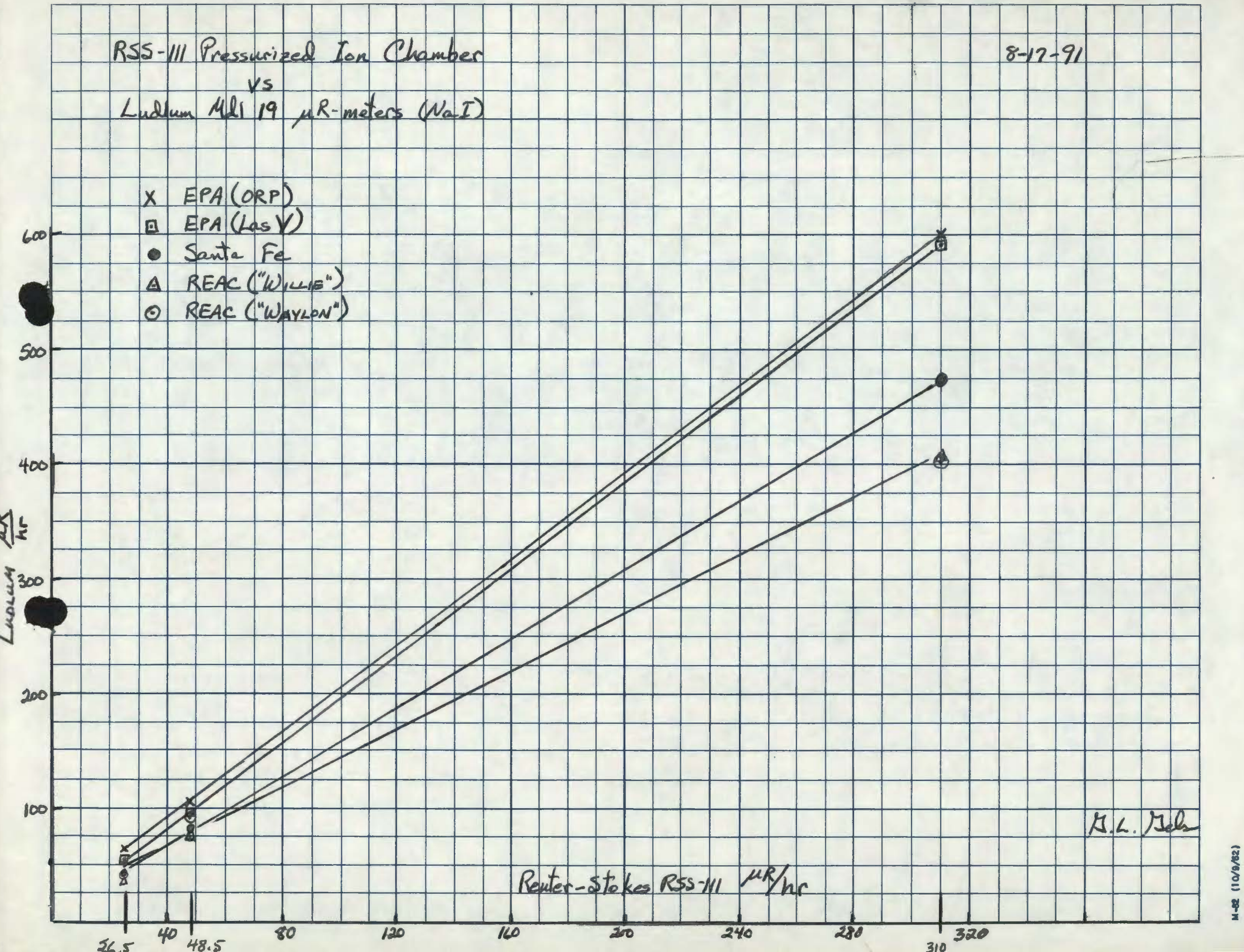
PIC Data (μR/hr):

26.1	25.9	26.5
26.2	26.3	27.4
26.0	27.7	26.8
25.5	26.8	26.1
27.2	26.8	25.5
25.8	28.2	25.9
25.7	27.3	

26.5 ± 0.74

GL Gelo

M-82 (10/9/82)


RSS-111 Pressurized Ion Chamber
VS
Ludlum Mdl 19 µR-meters (Na-I)
8-17-91
X EPA (ORP)
EPA (Las V)
Santa Fe
REAC ("Willie")
REAC ("Waylon")
600
500
400
300
200
100
Ludlum µR/hr
Reuter-Stokes RSS-111 µR/hr
26.5
40
48.5
80
120
160
200
240
280
310
320
G.L. Gels
M-82 (10/8/82)

Date	Time	Location	Zero	Cal.	Duration of Meas	Aerosol Conc. Range, ug/L
8/20/91	08:50	HP checkpoint (cp)	-.000	2.5	5 min	to .006 ug/L
	09:20	30-200 m North of dozers	—	—	3	to .007
	09:40	50-150 m N of dozers	-.004	—	3	0.00 to 0.016
	11:45	HP cp downwind	-.000	2.5	2	to .004
	16:37	HP cp upwind	-.000	—	3	.003 to .012
8/21	08:50	140-200 m downwind of dozers	-.000	—	2	.006 to .012
	09:10	"	.002	—	3	.008 to .016
	10:50	HP cp	-.000	—	4	.003 to .006
	15:27	30-200 m downwind (SW)	-.000	—	5	.000 to .005
	15:49	HP cp	-.000	—	2	.000 to .006
	15:51	HP cp - car passes within 4 ft.	—	—	0.5	.002 to .023 to .003
8/22	09:00	HP cp - downwind	-.000	2.5	5	.003 to .006
	14:30	200-500 m south of 3 dozers	-.000	2.5	10	.001 to .013
8/23	09:00	HP cp	-.000	2.5	6	.003 to .005
	14:32	HP cp	-.000	2.5	8	.003 to .005
8/24	08:59	HP cp	-.000	2.5	7	.001 to .007
	09:17	~75 m NW of a dozer	-.000	2.5	15	.000 to .012
	09:40	SW portion of Sec 24	-.000	2.5	5	.002 to .005
8/26	08:58	HP cp	-.000	2.5	10	.006 to .014

M-82 (10/9/82)

Ken ①

B:\DESIDERO
C:\LOTUS\REAC4 — DATA SAVED

	Grid		μR/hr			Grid		μR/hr	
	S	W	Wst	Gnd		S	W	Wst	Gnd
	19	34	30	50		11	32	250	800
	18	36	20	30		11.5	33	110	110
	15.5	34.5	10	10	30	10	28.6	300	1500
	15	37	30			6	26.8	250	500
	14.5	39	100	200		6.9	26.8	400	3000
	14.5	40	10	20		7.3	26.3	300	300
	13	41	200	500		6.8	25.9	50	50
	12	41	200	400		5.8	25.9	30	30
	5.5	34.5	200	380		5	25	25	25
	5.25	34.25	200	400		5.2	22.5	28	28
	5	34.1	300	500		6	21	20	20
	4.6	33.7	300	500		7	20	30	30
	4	33.8	500	800	40	7.5	19	32	32
	11	36	10	50		9	19	120	300
	12	36	500	500		9.1	17.9	50	50
16	12	36.8	170	200		1.0	18	50	50
	12	37.5	250	600		10.5	18.8	100	800
					45	10.5	18.9	50	50
	12	39	310	1000		10	19.4	35	35
	12	40	40	48		9.2	20.3	35	35
	12.7	39	110	250		9	19.8	30	30
	12.7	37	180	400		8.4	20.4	30	30
	12.7	36.1	130	110	50	8.6	21.1	38	38
	12.7	34.5	310	380		6.9	22.5	30	30
24	13.5	31	100	130		6.7	24.3	50	50
	13	30	100	110		6.8	25.1	80	80
	13.8	30	80	80		7.1	25.1	110	170
	11.5	29.5	130	130		11.1	22.5	100	100

Ken ②

	Grid		µR/hr	
	S	W	Wst	Gnd
#56	11.2	21	150	150
	12.8	19.9	100	100
	13.3	18.2	110	110
	16.2	25.5	100	300
	16.5	25.3	400	
	15.5	24		150
	16.5	23.3	350	
	14.3	22.3	35	35
64	14	21.5	50	50
	15.3	23.3	100	100
	14	21	50	50
	12.5	21.9	75	75
	13	20.5	135	140
	13.6	20	65	65
70	14	16.5	600	2000
	7.7	17.5	24	24
	5.4	14.1	35	35
	5.8	13.9	50	70
	5.2	13.6	35	35
75	4.9	13.2	35	35
	4.1	11.7	28	28
	4.8	11.7	25	25
	3	9.2	60	500
	3.3	7.9	40	70
80	3.8	8	60	100
	4.2	9.5	35	35
	4.5	7.2	35	35

	Grid		µR/hr	
	S	W	Wst	Gnd
83	7.3	7.1	50	50
	7.8	6.9	50	400
85	8.5	5.6	35	35
	9.2	5.3	40	75
	9.5	5.2	50	50
	10	5	65	750
	11.5	6	30	30
90	11.85	6.5	75	300
	9.9	6.6	45	45
	9.2	7.5	50	50
	8.7	7.8	75	75
	7	7.8	45	45
	6.3	8	35	35
	7.4	9.2	50	50
	6.2	9.4	50	50
	5.3	10	130	1000
99	4.8	9.3	35	35

NSF ①

Patrick Stanley (Waylon)

	Grid S	Grid W	µR/hr Wst	µR/hr Gnd
	25	26.2	16	
	24.5	25.9	16	
	24	26	20	
	23.8	25.1	25	
	24.1	25.1	30	
	21.2	25.9	60	
	19.1	25.9	30	
	18	26.1	75	
	17.4	25.5	90	
10	12.6	24.7	140	
	18.8	25.1	80	
	17.3	23.2	30	
	20.2	24.8	70	
	20.8	24.2	70	
15	21.5	23.9	28	
	22.8	23.3	30	
	22.4	22.5	75	
	22	22.5	110	
	21.3	22.5	120	
20	22	23	110	
	20.9	23	24	
	21.1	22.1	80	
	21.7	22	80	
	22.2	22	90	
25	23.1	22	50	
	23.7	23.2	~~88~~15	
	22.9	21.1	~~100~~80	

	Grid S	Grid W	µR/hr Wst	µR/hr Gnd
	22.5	21.4	120	
	21.8	22.2	~~60~~110	
30	21	21.6	60	
	20.4	22.2	24	
	20.3	23.1	24	
	19.9	22.9	24	
	19.2	23.9	26	
35	18.5	23.3	24	
	18	22.6	24	
	18	23.5	24	
	21	25.2	30	
	22.3	24.3	32	
40	22.5	20.6	22	
	20.3	21.0	120	
	20.2	21.5	110	
	20.0	21.2	22	
	18.7	21.3	20	
45	17.0	21.6	28	
	16.6	22.4	40	
	15.5	21.6	240	
	15.0	21.6	60	
	16.7	21.0	60	
50	17.0	20.6	130	
	17.1	20.2	150	
	17.0	19.4	110	
	17.7	19.5	26	
	18.7	20.6	20	

NSF ②
(Waylon)

	Grid		µR/hr			Grid		µR/hr	
	S	W	Wst	Gnd		S	W	Wst	Gnd
55	18.4	19.6	22		82	17.0	18.5	100	
	19.3	17.3	20			17.1	17.8	230	
	20.1	18.1	80			16.5	17.3	120	
	20.2	18.6	140		85	16.0	18.5	240	
	20.8	18.5	220			15.7	18.0	220	
60	21.3	18.9	190			15.5	18.6	150	
	20.2	19.1	200			15.3	19.1	150	
	20.6	19.5	100			16.4	19.0	130	
	2		120		90	16.5	19.4	150	
	20.1	19.5	100			16.0	19.3	150	
65	21.6	18.6	165			16.2	20.0	160	
	21.2	17.7	210			15.5	20.2	155	
	20.7	17.6	140			14.8	19.6	150	
	21.7	18.1	140		95	17.0	17.0	90	
	21.4	17.6	150			15.6	16.5	250	
70	21.7	18.0	120			14.9	16.1	440	
	21.8	17.8	18			15.3	15.1	800	
	21.7	18.9	135			14.8	13.8	300	
	21.9	20.0	18		100	16.0	13.4	700	
	20.2	15.1	18			16.7	12.0	300	
75	18.6	14.0	34			14.2	15.2	50	
	18.0	14.5	70			15.0	12.5	220	
	18.3	16.1	20			15.0	11.6	70	
	17.8	17.0	32		5	14.8	10.8	220	
	17.4	18.5	130			16.3	11.0	400	
80	17.0	18.8	110			18.2	10.0	26	
	16.7	18.3	100			19.6	8.8	260	

NSF ③
(Waylon)

	Grd		uR/hr	
	S	W	Wst	Cond
109	20.0	10.0	200	
110	20.3	11.1	130	
	20.7	12.0	150	
	22.0	10.0	15	
	18.0	6.8	18	
	16.9	4.5	17	
115	15.3	6.2	70	
	15.1	7.2	110	
	16.2	9.1	36	
	15.6	8.5	150	
	14.7	9.5	46	
120	12.5	6.2	22	
	13.9	4.9	90	
	14.7	4.7	140	
	14.2	3.6	80	
	11.2 ~~14.9~~	4.0 ~~4.5~~	40	
125	11.9	2.1	60	
	13.5	3.0	85	
	11.2	1.1	45	
	13.0	0.6	26	
	14.6	0.8	14	
130	10.0	2.0	21	
	9.3	0.6	16	

135

Art Ball
(Willie)

Grid µR/hr

	S	W	Wst	Grnd
1	23.8	30.7	15	15
.	22.9	28.3	20	20
.	22.0	28.0	30	30
.	21.6	28.7	30	40
5	21.9	29.6	15	15
.	21.6	31.9	30	30
.	20.0	32.0	20	20
	19.7	30.0	50	500
	20.4	28.3	100	260
10	21.0	27.0	180	240
.	22.8	27.1	50	50
.	22.0	26.3	70	130
.	21.0	26.2	120	230
.	19.7	26.4	50	50
15	19.2	27.7	24	24
.	19.2	29.0	30	18
.	19.1	30.9	20	20
.	19.3	32.9	20	22
.	20.5	33.3	14	14
20	17.7	30.5	20	18
.	16.6	29.2	20	24
.	18.2	28.5	20	20
.	16.7	28.0	18	18
.	15.0	28.1	32	28
25	14.4	27.3	30	24
	13.9	27.0	50	50
	~~21~~ 14.4	26.2	38	40

	S	W	Wst	Gnd
28	15.7	27.2	48	32
.	15.0	27.3	68	80
30	12.6	26.8	150	320
.	12.8	25.1	50	50
.	12.0	25.8	30	24
.	11.2	25.7	50	50
.	11.5	26.6	100	100
35	11.9	24.3	32	28
	10.4	25.5	150	300
.	9.5	25.5	100	130
.	10.0	26.5	130	150
	7.1	26.0	140	120
40	8.9	26.8	60	50
.	9.2	24.8	150	120
.	11.0	24.4	320	2000
	8.1	25.5	30	30
.	9.1	22.8	70	50
45	8.9	21.2	26	20
.	10.3	22.2	50	60
.	9.5	20.8	40	38
.	8.9	21.1	26	28
.	8.0	23.5	30	30
50	9.2	23.9	40	30
.	13.7	14.3	32	32
.	13.2	16.2	44	40
.	13.2	17.6	180	600
.	12.1	17.7	50	50

Art Ball
(Willie)
-cont-

μR/hr

	Grid S	Grid W	Wst	Gnd
55	10.4	17.3	24	20
·	9.4	17.3	24	22
·	8.8	18.2	25	22
·	7.5	17.8	25	22
·	7.1	16.6	15	15
60	8.4	17.2	16	16
·	8.2	15.8	18	18
·	8.3	14.5	22	20
·	9.5	14.2	30	20
·	10.0	16.0	20	20
65	11.0	15.2	24	22
·	11.1	14.1	30	22
·	11.4	12.6	26	20
·	12.6	12.1	30	25
·	12.8	13.9	25	22
70	13.8	13.1	100	200
·	13.9	10.9	26	28
·	12.0	9.8	46	55
·	11.5	9.0	130	260
·	10.3	8.2	40	25
75	9.7	9.6	100	70
	8.2	11.0	180	180
·	8.0	12.3	200	360
	7.0	12.0	240	320
·	6.4	13.8	24	24
80	9.5	12.9	170	200
	10.2	12.1	300	380
82	10.5	11.0	160	110
	11.2	9.8	36	24
	12.5	10.3	25	24
85	13.0	8.5	160	140
·	10.6	7.5	34	27
·	9.0	8.0	300	2400
·	8.8	7.8	70	225
·	9.1	6.4	50	60
90	10.2	6.5	40	34

	N-0	N-1	N-2	N-3	N-4	N-5	N-6
E-0	11	17	12	15	12	12	15
1	39	13	13	22	13	15	25
2	12	14	13	12	13	13	[illegible]
3	11	12	13	11	02	24	15
4	11	12	13	15	17	11	17
5	14	15	12	11	12	12	12
6	14	12	11	12	12	11	10
7	12	12	12	10	11	14	
8	13	14	14	50	20	18	
9	13	19	16	18	30	14	
10	13	40	18	14	30	18	
11	15	22	28	25	~~90~~ 14	13	

Random Gamma Survey - Desiderio - N of Lg Pit.

15 $\mu R/hr$ (1) Near Pinion tree (lg) near road NW of Pit

50 $\mu R/hr$ (2) About 100 ft E of lg. pinion pine in (1)
10 ft toward road = 15 $\mu R/hr$.

40 $\mu R/hr$ (3) About 200 ft E of lg pinion pine in (1), near where lg pit began.

22 $\mu R/hr$ (4) About 100 ft S of sign. About 400 ft E of pinion in (1)

15 $\mu R/hr$ (5) About 100 ft E of (4). Also 100 ft from road.

16 $\mu R/hr$ (6) Near tree by road 100 ft N of (5).

15 (7) Half way between E road sign + 1st tree (6).

15 (8) Near Fence halfway between Road & Gulley (Pit)

20 (9) 30' behind sign where mine used to be

20 (10) 50' North of reading (9) on top of mine opening

40 (11) Highest reading above where mine opening was (area ...)

36 (12) Drilled hole ~ 50' South of lone Pinion ...

24 13 Cleared area between mine and fence

24 14 ~100' west of fence on roadway next to Pit

35 15 ~200' " " " " " " " "

22 16 in Gulley between Pit & Mine

38 17 old road halfway between sweat box & gulley

13 18 Middle of road between sign & Pit

12 19 Between skull tree & Pit ~100' West of #18

12 20 West end of gulley ~300' E of staging area

12 21 100' E (downstream in gulley) of #20

12 22 another 100' downstream next to tree in gulley

15 23 " " " in gulley

20 24 " " " " " near end

40 25 Near Bush at fence end of pit

20	26	Top of small hill near Main Rd & driveway
15	27	Top of dike between small & large hills
14	28	Top of large hill - west end
20	29	" " " " East "
20	30	Face of East slope large hill near top
14	31	" " " " " " middle
17	32	" " " " " " near bottom
28	33	Around base of dirt pile near Pedro's Pit
32	34	Edge of upper bluff above Pedro's Pit
30	35	S. end of Pedros Pit near juniper
34	36	Edge of affected mine area S. of Pedros Pit
40	37	East edge of Pedro's Pit
45	38	North " " " "
30	39	Between dirt Pile & Pedro's Pit
38	40	Bottom of Ravine at East end of large pit
26	41	200' from fence " " " " " "
22	42	Bottom of large pit
50	43	West End of " " ~ 100' S. of Sign
17	44	N.W slope of large hill
20	45	West " " " "
18	46	SW " " " "

Sec 18

POST

	N 12	N 11	N 10	N 9
E-0	12	10	10	12
E-1	14	12	12	10
E-2	10	14	12	12
E-3	10	12	10	10
E-4	10	12	14	12
E-5	10	10	12	12
E-6	10	12	10	8
E-7				10

	N 8	N 7	N 6	N 5	N 4
E-0	10	10	10	12	12
E-1	14	34	12	12	10
E-2	12	12	10	10	8
E-3	10	10	10	14	16
E-4	12	12	10	12	12
E-5	16	20	12	18 (30)	12
E-6	10	12	12		

	N 3	N 2	N 1
E-0	12	12	
E-1	10	12	
E-2	14	12	
E-3	20 (40)	16	
E 4	10	14	
E 5	12		

$\frac{2038}{157 \text{ readings}} = 13$ avg

13 X 12
~~2 X 14~~
7 X 18

N12		N11		N10	N9
W1	12	W1	12	→ 12	12
2	12	2	14	→ 12	12
3	12	3	14	→ 12	12
4	12	4	12	→ 18	12
5		5		→	

	N8		N7		N6		N5	
	1	12	1	12	1	12	1	12
	2	12	2	12	2	12	2	14
	3	12	3	12	3	12	3	14
POND	4	12	4	12	4	12	4	12
Area	5	12	5	14	5	14	5	14
	6	12	6	12	6	16	6	12
	7	12	7	12	7	14	7	12
							8	12

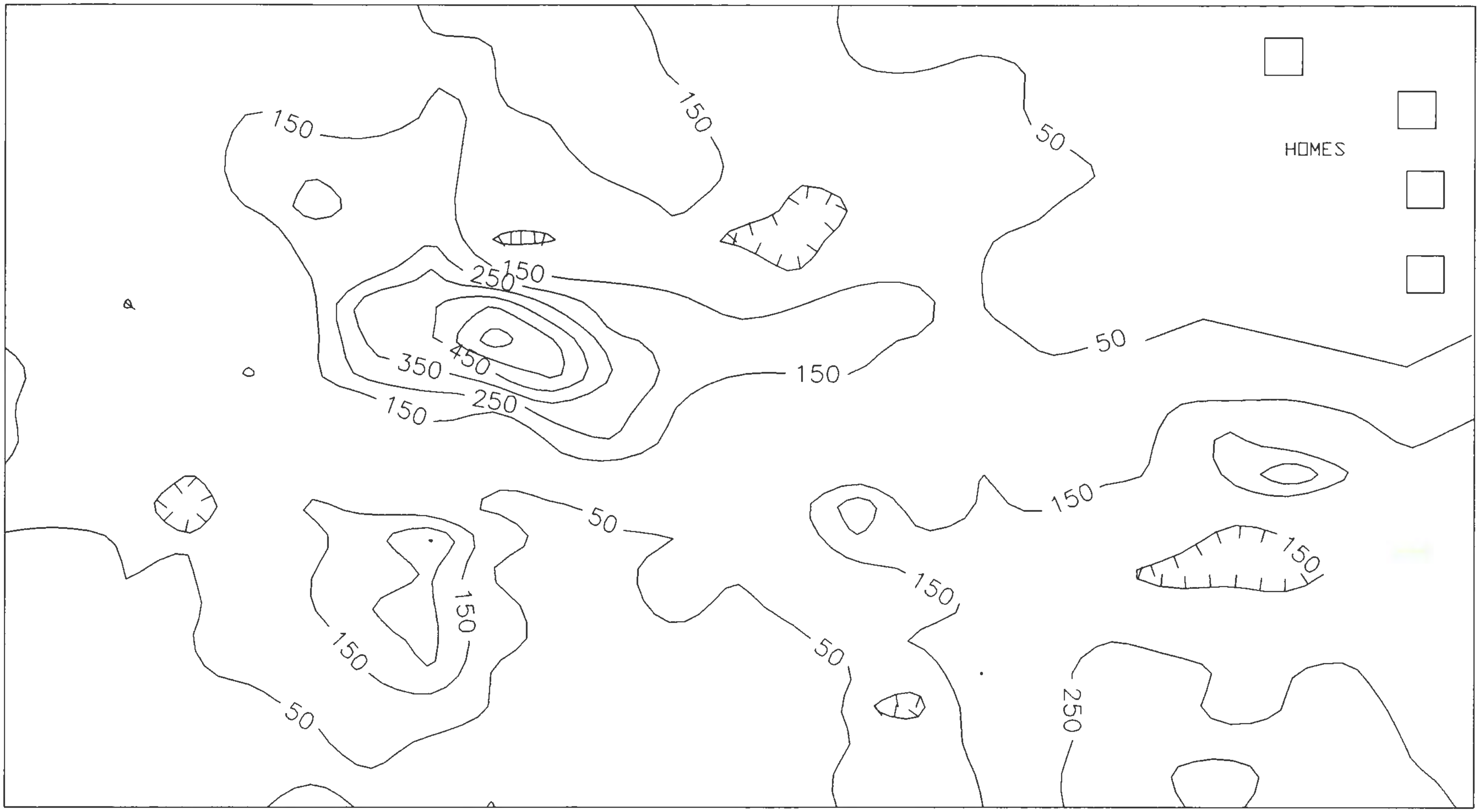
~~22 X 12~~
~~6 X 14~~
~~1 X 16~~

~~24 X 12~~
~~4 X 14~~
~~2 X 15~~
~~2 X 16~~
2 X 18

N4		N3		N2		N1		N0	
1	14	1	12	1	12	1	12	1	14
2	12	2	14	2	14	2	12	2	18
3	16	3	12	3	12	3	12	3	20
4	12	4	12	4	12	4	12	4	18
5	12	5	12	5	12	5	12	5	16
6	12	6	15	6	12	6	24	6	12
7	12	7	12	7		7	15	7	12
8	12	8	12	8		8	16	8	

20
24

PRE-RECLAMATION
NAVAJO-DESIDERIO MINE SITE



LEGEND

VALUES IN uR/Hr

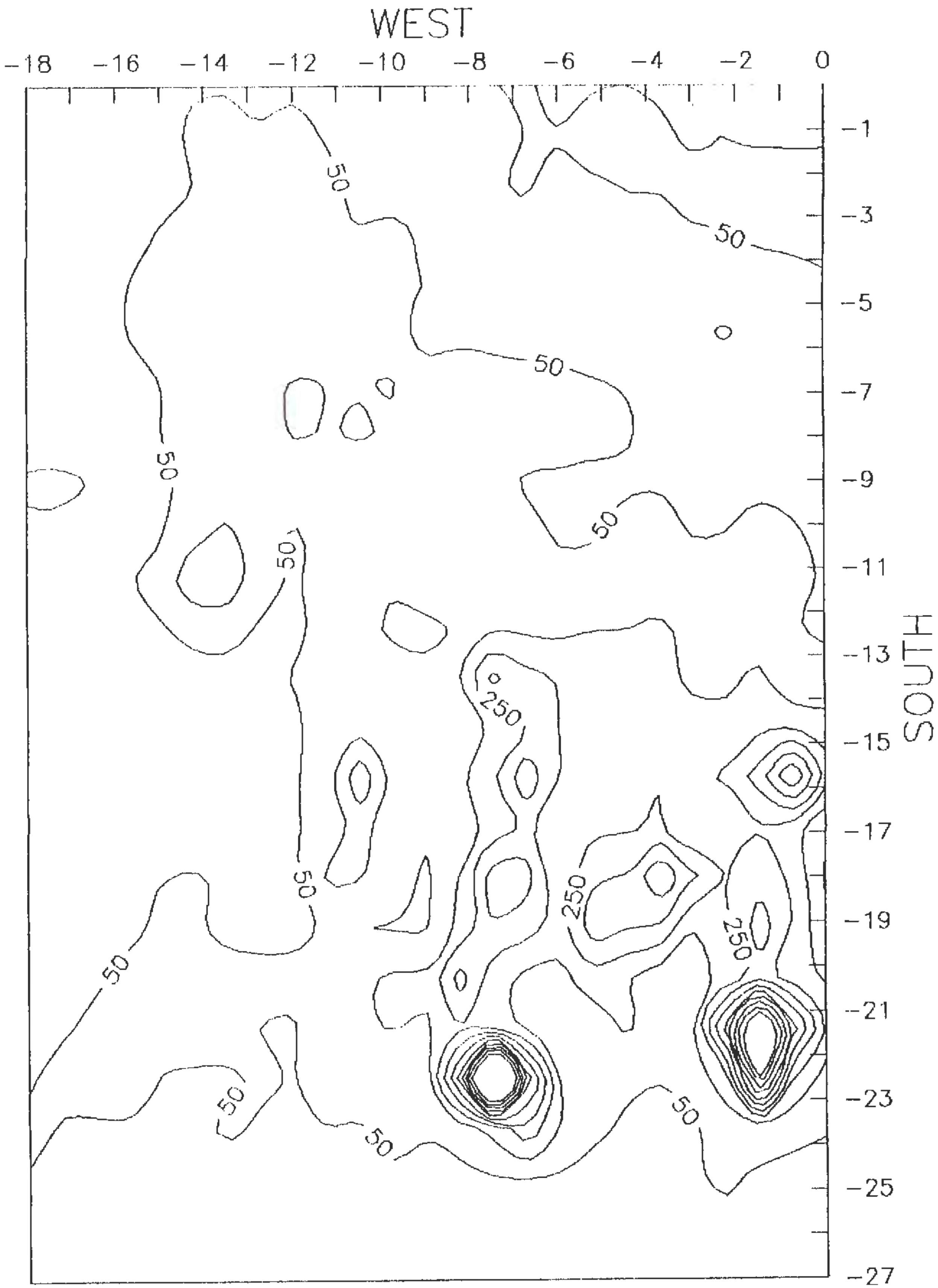
Survey Conducted on 100' X 100' Grid

Waist Level Measurements
100 uR/Hr Contour Interval

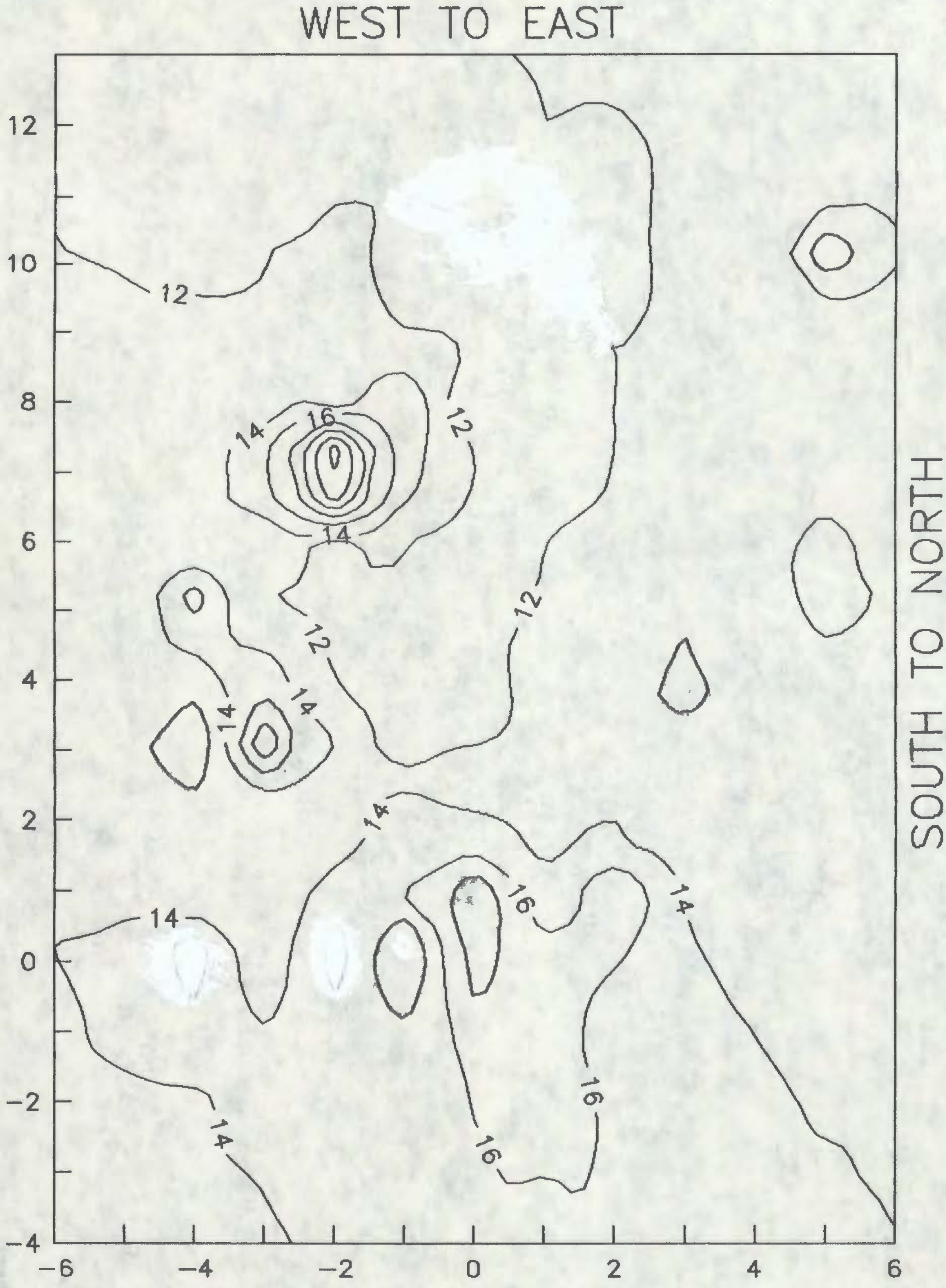
N

ERS Graphics 9/91

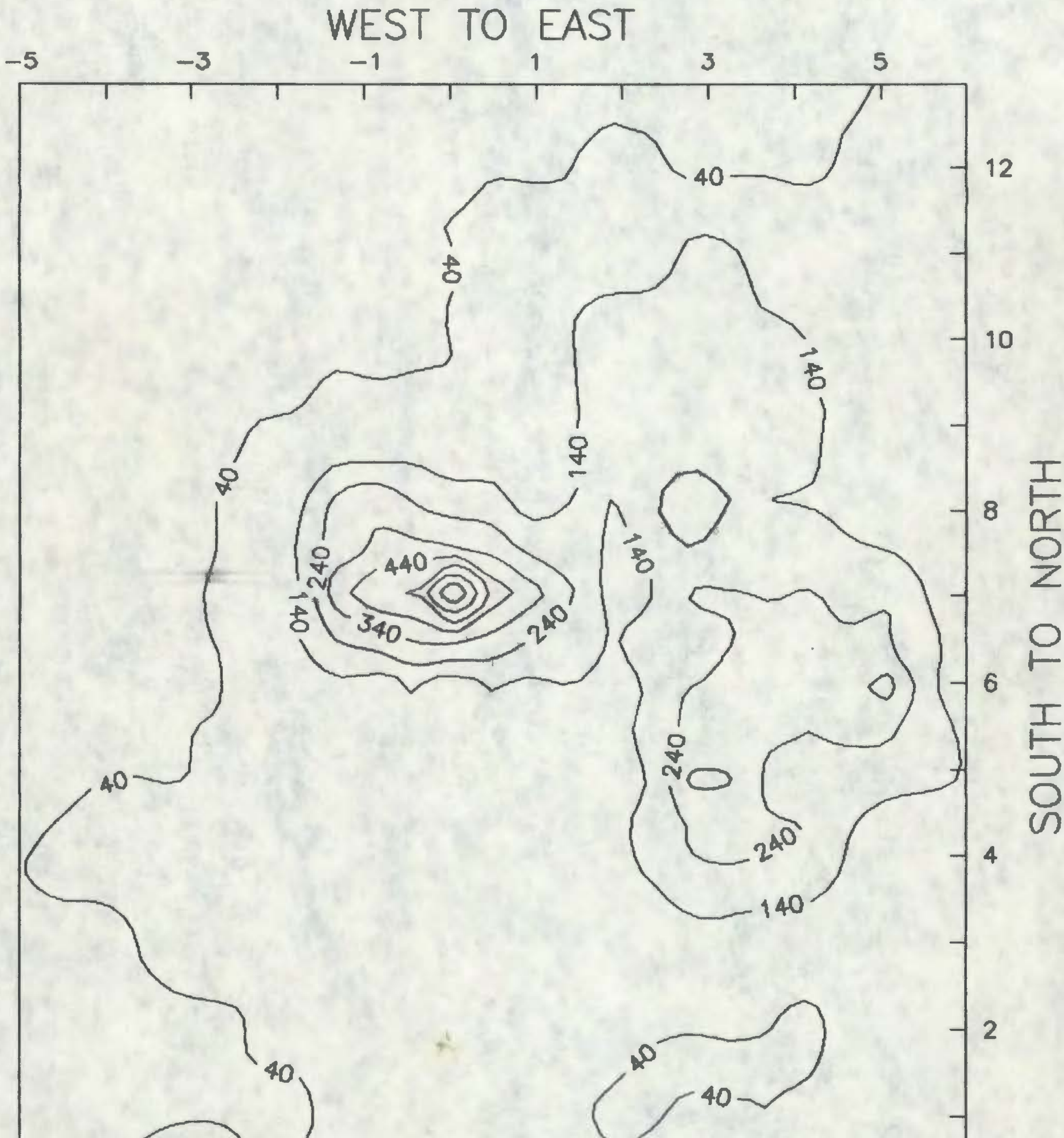
WAIST GAMMA SURVEY, SEC. 24 BV (uR/Hr)

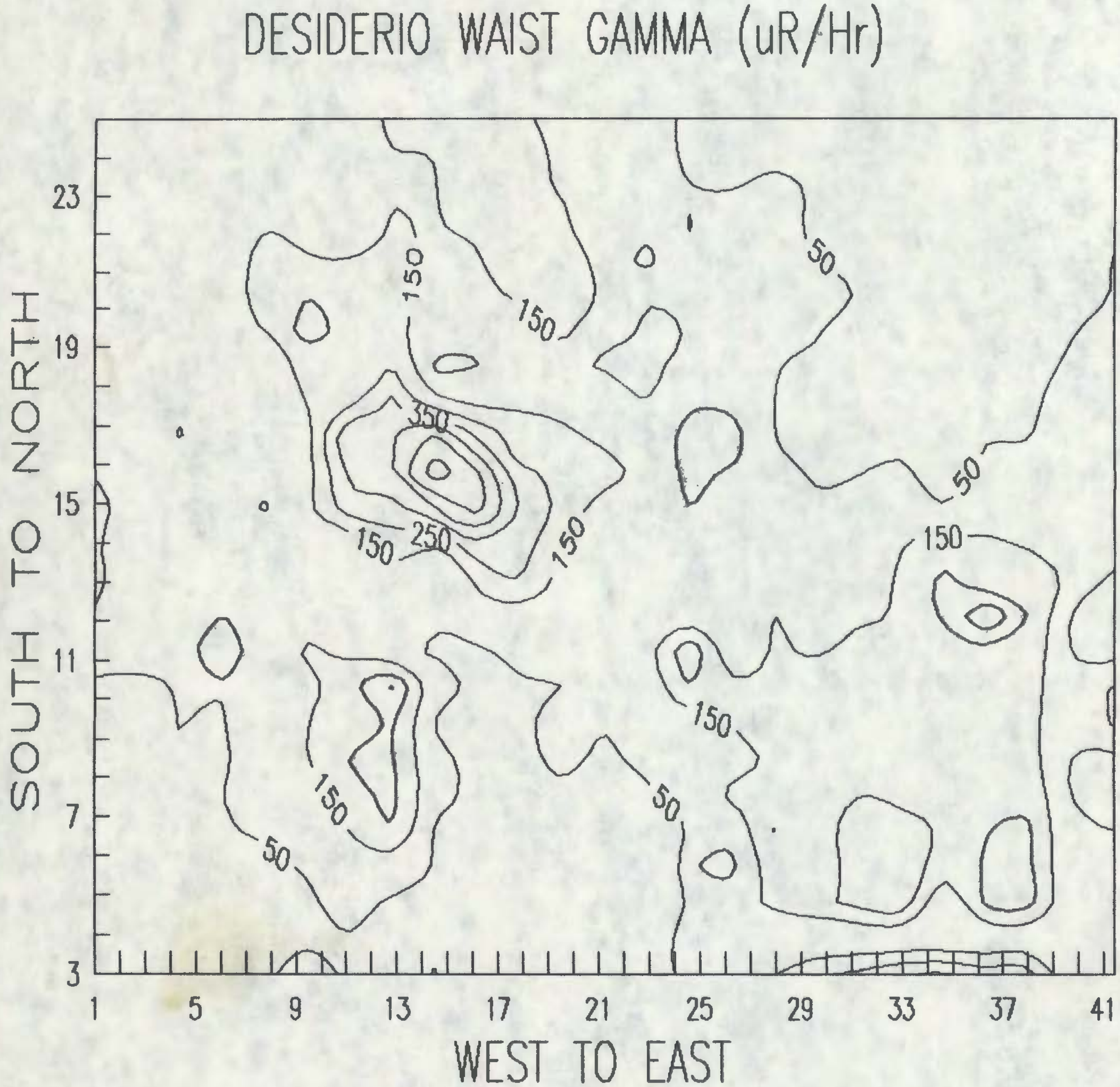


POST WAIST SURVEY, SEC. 18 (uR/hr)



WAIST LEVEL GAMMA SURVEY, SEC. 18 BV (uR/Hr)




DESIDERIO WAIST GAMMA (uR/Hr)
SOUTH TO NORTH
23
19
15
11
7
3
1
5
9
13
17
21
25
29
33
37
41
WEST TO EAST
150
150
350
250
150
150
50
50
150
150
150
50
50

Justification for use of Ludlum model 19 survey meters as standard measurement instruments on the Bluewater Uranium Mill Site

Because of differences in readings taken with the several different Ludlum Model 19 gamma survey meters (19's), a Reuter-Stokes Model RSS-111 pressurized ion chamber (PIC) serial number 5854 with readout serial number Z5880 was borrowed from the Office of Radiation Programs (ORP) facility in Las Vegas. Comparison of gamma exposure field readings taken with the PIC and the 19's showed that the 19's indicated higher exposure ~~fields~~ reading ~~in all cases~~ than the PIC in all cases. The difference ranged from factors of 1.3 to 2.3.

The energy response curve for the PIC indicate that efficiency drops off sharply for low energy gamma and X-ray emissions. The Uranium ore which is the source of the gamma exposure at the Bluewater sites emits some low energy gammas and X-rays which will not be efficiently detected by the PIC. Two of the ~~sold~~ 19's, serial numbers 53216 and 30756 had recently been calibrated at the ORP Las Vegas facility. These instruments had the greatest difference in readings from the PIC - 2.0 to 2.3 times the readings. Their readings were essentially identical.

Adopting the principle of erring on the safe side, I recommended that these 19's should be used as the standard for gamma exposure field surveys. Correction factors were then calculated for the other two 19's - serial numbers 36518 and 36522 (code named "Willie" and "Waylon" respectively.)

Representatives from Santa Fe Pacific Minerals who are working a section near the Superfund site requested a comparison of their 19 with our instruments. Their instrument also read substantially higher than the PIC. However, when compared with the 19's which we adopted as standards, the correction factor recommended by their calibration facility proved to be correct. This supports my decision to recommend the ORP calibrated 19's a site standards.

Arthur E Ball
Env. Spec V
U.S. EPA

Instructions to Contractors.

Gerald Gels, Roy F Weston Co. REAC
Glen Rogers, Halliburton NUS Env. Corp. HMIRT

During my absence from the Bluewater Uranium Mine sites August 21-24, 1991 you are to complete characterization of the radiation exposure fields, ~~and~~ operate the Health Physics check station, Survey personnel and Equipment leaving the sites, and conduct post removal surveys of completed sections as requested by the ~~OA~~-Scene-Coordinator.

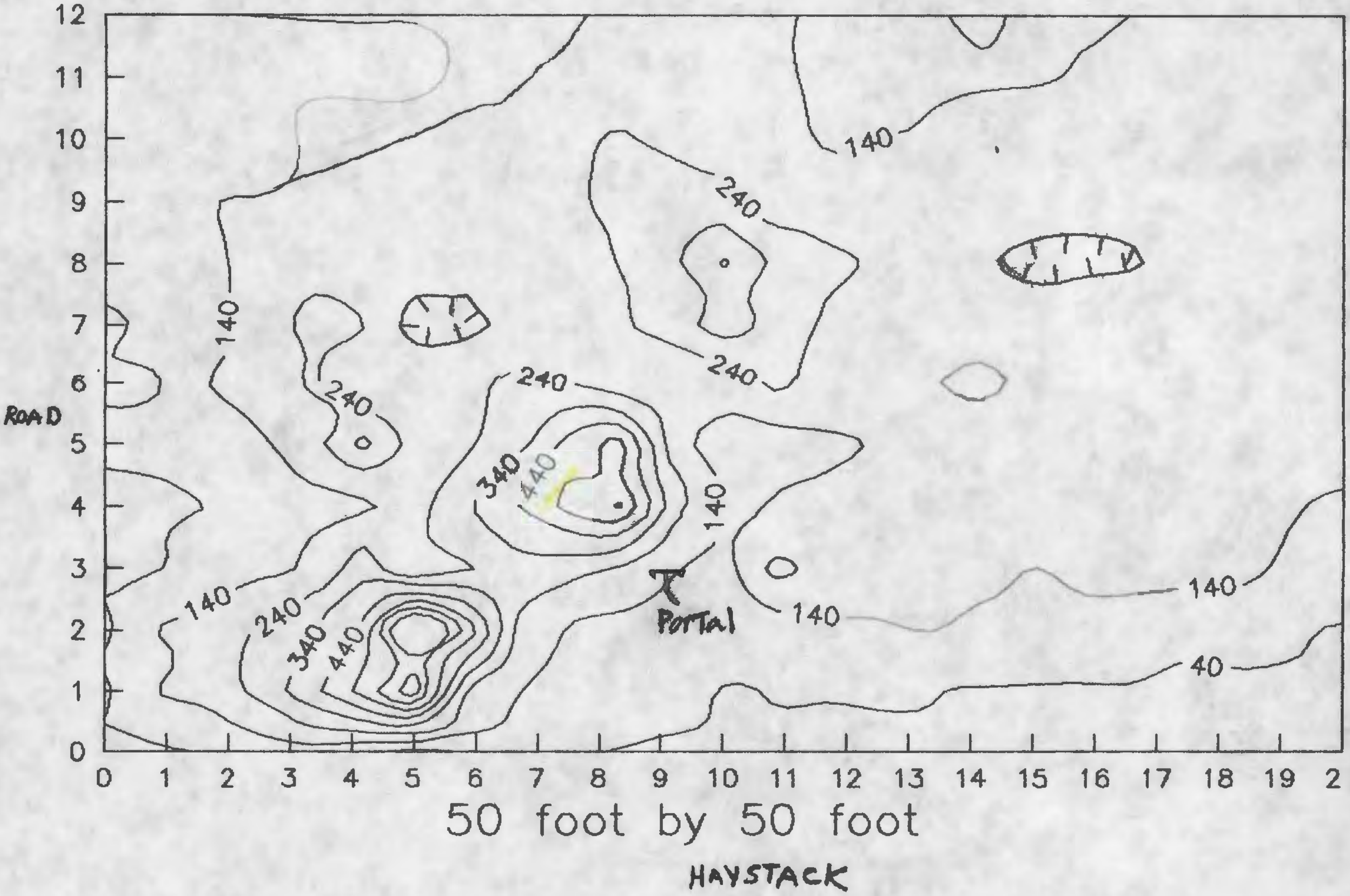
Arthur C Ball
Env. Spec V
U.S. EPA

Justification for not using Self-Reading Dosimeters at the Bluewater Uranium Mine Site.

The Gamma Radiation Survey ~~[illegible]~~ conducted on November 14 and 15, 1990 showed a maximum exposure field of 800 microroentgens per hour at waist level. Even if a person were to spend an ~~the~~ entire 10 hour work day in this maximum exposure field, the reading on a self reading pocket dosimeter (SRD) would ~~show~~ read less than one division (10 milliroentgens ~~[illegible]~~) on the 0 to 200 milliroentgens scale on the SRD. This would require daily readings of the SRD to be interpolations of hairline movement within the first division on the scale. SRD drift could move the hairline a division or more during this same time period. Also the very rugged terrain would increase the possibility of bumping, damaging or losing the dosimeters. Therefore, I recommended that SRD's not be used on the Bluewater Site.

Arthur C. Ball
Env Spec V
U.S. EPA

PRE GAMMA SURVEY, DOE BLUEWATER



DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Health Services Administration

Navajo Area
Indian Health Service
P. O. Box G
Window Rock, Arizona 86515

January 11, 1990

Bill Weiss
United States Environmental Protection Agency
Region 9
Field Operations
H83
75 Hawthorne St.
San Francisco, California 94105

Subject: Radon Survey of Navajo Nation

Mr. Weis:

Beginning in January of 1990 the Navajo Area Indian Health Service (NAIHS) initiated a survey of private Navajo homes for radon. This survey was sponsored by the United States Environmental Protection (USEPA) and coordinated through the Research Triangle Institute. The Navajo Environmental Protection Administration (NEPA) was consulted and assisted in the survey's development process.

The survey, as designed, consisted of two testing procedures; a single 2 day (48 hr.) charcoal canister test for radon in 90% of the homes surveyed, and a 1 year track-etch testing procedure for 10% of the homes surveyed. This latter testing procedure is currently ongoing, and the results reported herein refer only to the earlier 2 day (48 hr.) testing procedures, which took place between mid-January 1990 and the first week in March of the same year. Homes surveyed were selected via a statistically random process. Results are as reported by the USEPA, Region 9 Office of Radiation Programs.

Number of Homes Tested.	Estimated Number of Homes in Target Population	% Homes > 4 pCi/L	Arithmetic Mean pCi/L
772	33,354	8.3	1.7

As a result of this survey it appears that several homes near the Navajo-Brown Vanderver and Navajo-Desiderio, Bluewater, New Mexico uranium mining areas referred to in the Agency for Toxic Substances and Disease Registry's October 26, 1990 Public Health Advisory were tested. The result for these homes are reported as follows:

Selected 1980 US Census Enumeration District	Location Description	Reported Indoor Radon Activity pCi/L	% Error (2 Sigma)
New Mexico	Two Fault Butte Area	1.3	58.5
AED-1221 B	North of Prewitt, NM	1.0	70.3
		<1.0	NA
		2.4	30.9
		3.4	16.4
		1.4	50.8
		<1.0	NA
		1.1	63.2
New Mexico	Southwest of Prewitt, NM	1.6	50.8
AED-1202 B	South of I40	7.5	15.0
		4.5	23.2
		4.5	19.0
		1.8	55.4

(NA = Not Available)

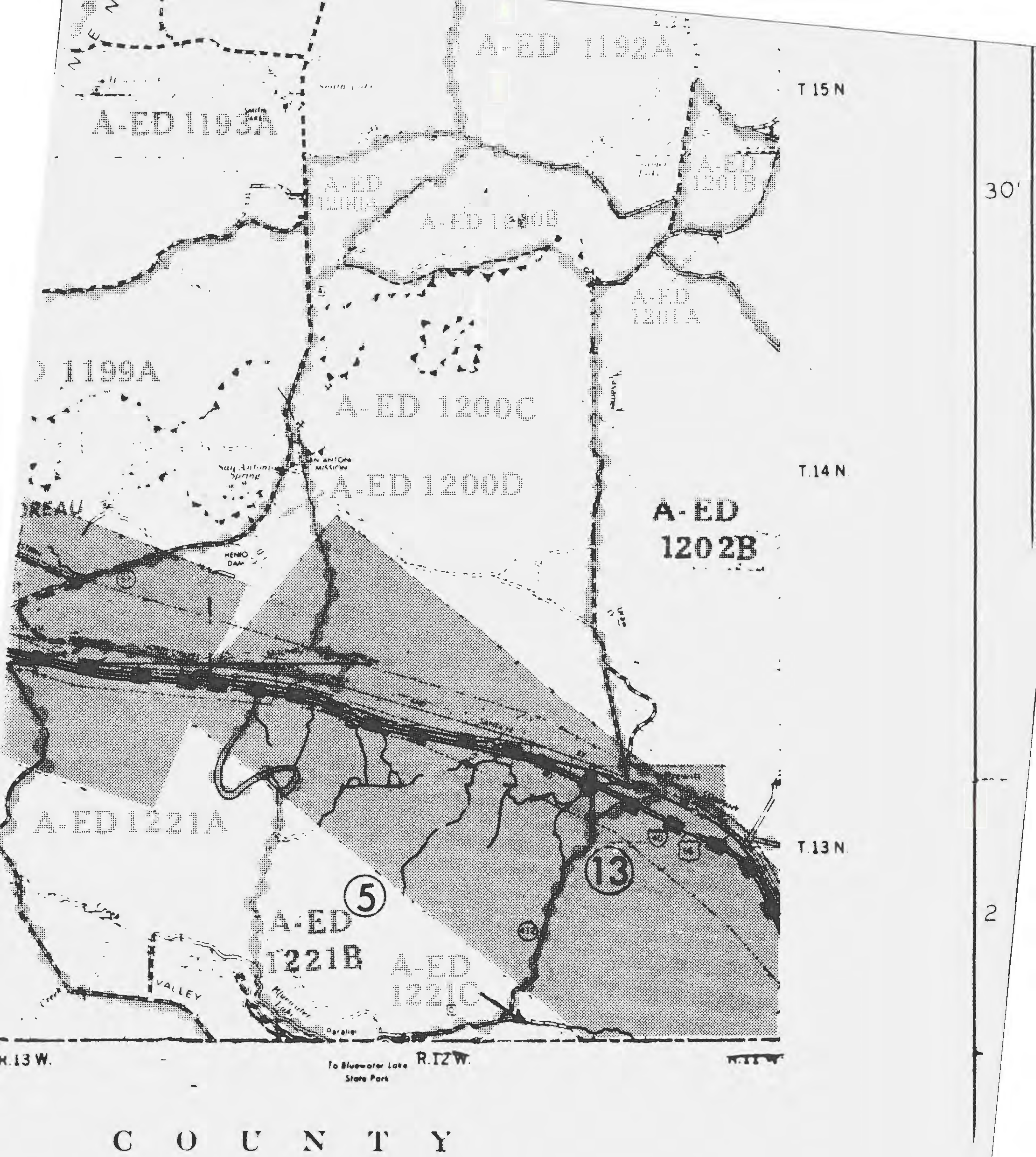
The enclosed map indicates the location of the above areas selected for the survey. The selected homes were in clustered locations within the the selected enumeration districts.

If you should have any questions, or if I may be of any further assistance, please call me at (602) 871-5851 or FTS 572-8396.

Sincerely:

Michael A. Taylor

Michael A. Taylor
Health Physicist
Occupational Health & Safety Management


A-ED 1192A
A-ED 1193A
T 15 N
A-ED 1201B
30'
A-ED 1201A
A-ED 1200C
A-ED 1200D
A-ED 1202B
San Antonio Spring
SAN ANTONIO MISSION
T.14 N.
A-ED 1221A
A-ED 1221B
A-ED 1221C
5
13
T.13 N.
2
VALLEY
Parallel
R.13 W.
To Bluewater Lake State Park
R.12 W.
C O U N T Y

EXPOSURES DUE TO RADON IN HOMES CAN NOT BE CALCULATED
FURTHER STUDY IS REQUIRED TO GATHER RELEVANT DATA
THESE CALCULATIONS SUPERSEDE THOSE OF MARCH 5, 1991, DUE TO MORE SPECIFIC DATA RECIEVED FROM THE NAVAJO NATION.

DIRECT EXTERNAL EXPOSURE ON THE NAVAJO BROWN VANDEVAR SITE USING SITE SPECIFIC TIME USE DATA PROVIDED BY THE NAVAJO NATION.
(The figures are in mili rem per year)

	TRADITIONAL FAMILY	CONTEMPORARY FAMILY
ADULT MALE	351.135	168.300
ADULT FEMALE	232.101	137.700
TEENAGER **	264.308	216.878
CHILD **	240.593	205.097
PRE SCHOOL CHILD	267.750	267.750

DIRECT EXTERNAL EXPOSURE ON THE NAVAJO DESIDERIO SITE USING SITE SPECIFIC TIME USE DATA PROVIDED BY THE NAVAJO NATION.
(The figures are in mili rem per year)

	TRADITIONAL FAMILY	CONTEMPORARY FAMILY
ADULT MALE	117.045	56.100
ADULT FEMALE	77.367	45.900
TEENAGER **	88.103	72.293
CHILD **	80.198	68.366
PRE SCHOOL CHILD	89.250	89.250

FACTS
=====

- AN AVERAGE EXPOSURE RATE OF 153 MICRO REM PER HOUR WAS CALCULATED FOR THE BROWN VANDEVER SITE
- AN AVERAGE EXPOSURE RATE OF 51 MICRO REM PER HOUR WAS CALCULATED FOR THE DESIDERIO SITE

ASSUMPTIONS
=========

- 50 WEEKS PER YEAR SPENT ON SITE
2 WEEKS PER YEAR SPENT ON VACATION, AWAY FROM THEIR HOME AND LAND

** In the event that a child and a teen exist in the same family, it is assumed that the herding chore is split, therefore, doses for the teen and the child would be halved.

·T=======

23-May-91

RESULTS SENT BY THE NAVAJO NATION'S SITE SURVEYS

NUMBER OF HOURS PER YEAR SPENT INSIDE THE HOME

	TRADITIONAL FAMILY	%	CONTEMPORARY FAMILY	%
ADULT MALE	5505	63%	4800	55%
ADULT FEMALE	6283	72%	5000	57%
TEENAGER	4746.5	54%	4934.5	56%
CHILD	4901.5	56%	5011.5	57%
PRE SCHOOL CHILD	6475	74%	5650	65%

NUMBER OF HOURS PER YEAR SPENT IN THE VISCINITY OF THE HOME

	TRADITIONAL FAMILY	%	CONTEMPORARY FAMILY	%
ADULT MALE	2295	26%	1100	13%
ADULT FEMALE	1517	17%	900	10%
TEENAGER	1727.5	20%	1417.5	16%
CHILD	1572.5	18%	1340.5	15%
PRE SCHOOL CHILD	1750	20%	1750	20%

NO OF HRS/YR AWAY FROM HOME AND LAND (INCLUDING 2 WKS VACATION)

	TRADITIONAL FAMILY	%	CONTEMPORARY FAMILY	%
ADULT MALE	936	11%	2836	32%
ADULT FEMALE	936	11%	2836	32%
TEENAGER	2262	26%	2384	27%
CHILD	2262	26%	2384	27%
PRE SCHOOL CHILD	511	6%	1336	15%

ASSUMPTIONS

- summer vacation lasts 12 weeks, (minus one week for vacation) = 11 weeks/yr
- school year lasts 40 weeks, (minus one week vacation) = 39 weeks/yr

22-May-91

RESULTS SENT BY THE NAVAJO NATION'S SITE SURVEYS
NUMBER OF HOURS PER WEEK

NUMBER OF HOURS PER WEEK SPENT INSIDE THE HOME

	SCHOOL YEAR		SUMMER VACATIONS	
	TRADITIONAL	CONTEMPORARY	TRADITIONAL	CONTEMPORARY
ADULT MALE	109	96	114	96
ADULT FEMALE	125	100	128	100
TEENAGER	93.5	95.5	100	110
CHILD	95.5	95.5	107	117
PRE SCHOOL CHILD	129.5	113	129.5	113

NUMBER OF HOURS PER WEEK SPENT IN THE VISCINITY OF THE HOME

	SCHOOL YEAR		SUMMER VACATIONS	
	TRADITIONAL	CONTEMPORARY	TRADITIONAL	CONTEMPORARY
ADULT MALE	47	22	42	22
ADULT FEMALE	31	18	28	18
TEENAGER	28.5	24.5	56	42
CHILD	26.5	24.5	49	35
PRE SCHOOL CHILD	35	35	35	35

NUMBER OF HOURS PER WEEK SPENT AWAY FROM THEIR HOME AND LAND

	SCHOOL YEAR		SUMMER VACATIONS	
	TRADITIONAL	CONTEMPORARY	TRADITIONAL	CONTEMPORARY
ADULT MALE	12	50	12	50
ADULT FEMALE	12	50	12	50
TEENAGER	46	48	12	16
CHILD	46	48	12	16
PRE SCHOOL CHILD	3.5	20	3.5	20

22-May-91

RESULTS SENT BY THE NAVAJO NATION'S SITE SURVEYS
SUMMER VACATIONS

NUMBER OF HOURS PER DAY SPENT INSIDE THE HOME

SUMMER	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	18	12	12	18
ADULT FEMALE	20	14	12	20
TEENAGER	14.8	13	16.4	14
CHILD	15.8	14	17.4	15
PRE SCHOOL CHILD	18.5	18.5	16.6	15

NUMBER OF HOURS PER DAY SPENT IN THE VISCINITY OF THE HOME

SUMMER	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	6	6	2	6
ADULT FEMALE	4	4	2	4
TEENAGER	8	8	6	6
CHILD	7	7	5	5
PRE SCHOOL CHILD	5	5	5	5

NUMBER OF HOURS PER DAY SPENT AWAY FROM THEIR HOME AND LAND

SUMMER	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	0	6	10	0
ADULT FEMALE	0	6	10	0
TEENAGER	1.2	3	1.6	4
CHILD	1.2	3	1.6	4
PRE SCHOOL CHILD	0.5	0.5	2.4	4

ASSUMPTIONS

- Parents do not herd during the summer.
- During the summer, parents have the children do all the herding. Child assumed to herd daily. Teen also assumed to herd daily. In the event that child and teen exists in same family, they would logically split the chore of herding. Must include in dose section: since they split chore in 1/2, therefore doses would be halved.

22-May-91

RESULTS SENT BY THE NAVAJO NATION'S SITE SURVEYS
SCHOOL YEAR

NUMBER OF HOURS PER DAY SPENT INSIDE THE HOME

SCHOOL YEAR	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	17	12	12	18
ADULT FEMALE	20	calculate	12	20
TEENAGER	13.5	13	13.5	14
CHILD	13.5	14	13.5	14
PRE SCHOOL CHILD	18.5	18.5	16.6	15

NUMBER OF HOURS PER DAY SPENT IN THE VISCINITY OF THE HOME

SCHOOL YEAR	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	7	6	2	6
ADULT FEMALE	4	4WD,7HERD	2	4
TEENAGER	2.5	8	2.5	6
CHILD	2.5	7	2.5	6
PRE SCHOOL CHILD	5	5	5	5

NUMBER OF HOURS PER DAY SPENT AWAY FROM THEIR HOME AND LAND

SCHOOL YEAR	TRADITIONAL FAMILY		CONTEMPORARY FAMILY	
	WKDAY	WKEND	WKDAY	WKEND
ADULT MALE	0	6	10	0
ADULT FEMALE	0	6	10	0
TEENAGER	8	3	8	4
CHILD	8	3	8	4
PRE SCHOOL CHILD	0.5	0.5	2.4	4

ASSUMPTIONS

- Male herd sheep 5 days/wk
- Female herd sheep 1 day/wk
- Teen/child herd sheep 1 day/wk
- Assume that family does not contain a teen and a child.
- NOTE: have combined sheep herder scenario into trad. scen. from Rajen.

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Environmental Protection
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Radiation

EPA

RADON FLUX MEASUREMENTS ON GARDINIER AND ROYSTER PHOSPHOGYPSUM PILES NEAR TAMPA AND MULBERRY, FLORIDA

Prepared for
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METHOD

MEASURING RADON FLUX USING LARGE-AREA COLLECTORS

The method used to make radon flux measurements involves absorption of radon on activated charcoal in a large-area collector. This method, with many different geometries of collectors, has been used extensively since the publication of the paper by Countess (1976). The radon collector is placed on the surface of the material to be measured and is allowed to collect radon for a time period of up to 24 hours. The radon collected on the charcoal is then measured by gamma spectroscopy.

The PNL method differs slightly from other published methods in that a much larger area collector is used (Figures 1 and 2). The 0.052-m^2 collector is fabricated from a 10-in.-dia PVC end cap used for irrigation systems. The end cap is very rugged, therefore ideal for field use. The design of the collector, as shown in Figure 1, minimizes the space between the surface of the material being measured and the activated charcoal in the collector. This air gap must be minimized to obtain a valid radon flux measurement.

The collector consists of the PVC end cap, spacer pads, charcoal distribution grid, a retainer pad with screen, and a steel retainer spring (Figure 2). Approximately 170 grams of activated charcoal is spread in the distribution grid. The retainer pad is placed over the charcoal and held in place by the retainer spring.

The collectors are deployed by firmly twisting the end cap into the surface of the material to be measured. The deployment location and time are recorded in a notebook. After ~24 hours of exposure, the collectors are picked up and the time is recorded in the notebook. The activated charcoal is removed from the collector by removing the retaining spring and pad from the collector and dumping the charcoal into a large bowl. The charcoal is then placed and sealed in plastic containers ("cottage-cheese cartons" or equivalent) supplied by the EPA. The radon collected on the charcoal is allowed to equilibrate for 4 hours before counting to allow the ingrowth of radon daughters.

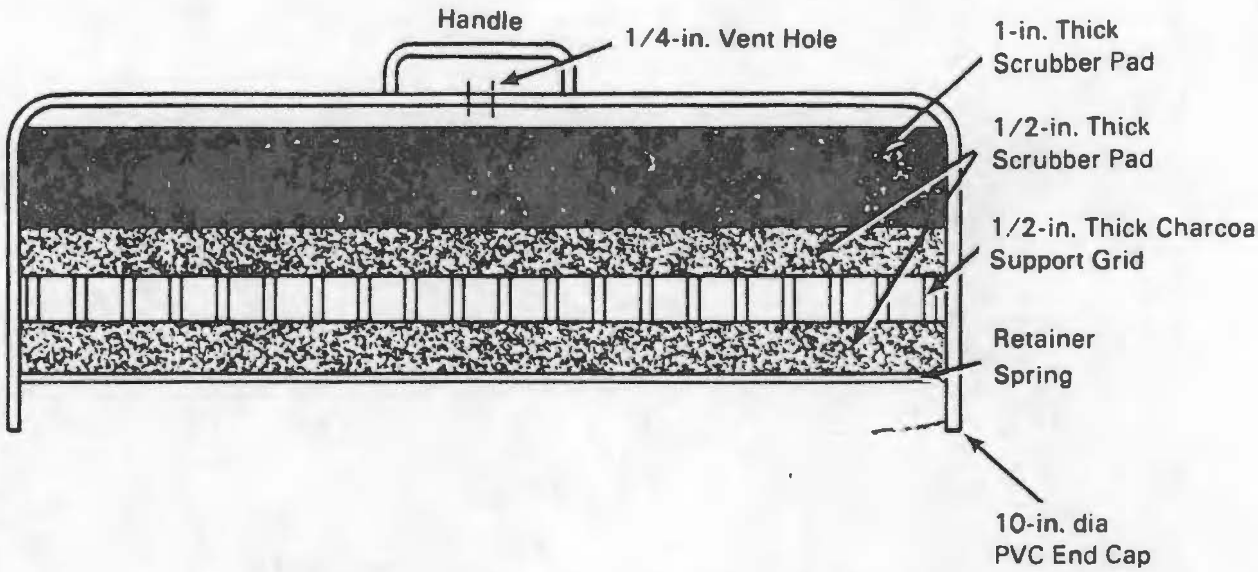

FIGURE 1. Large-Area Radon Collector

The amount of radon sorbed on the activated charcoal is determined by gamma spectroscopy. The gamma spectroscopy system used in this study consisted of a NaI(Tl) crystal, photomultiplier tube, amplifier, and scaler. The 609-keV ^{214}Bi radon decay product peak is used to quantify the radon on the charcoal. A National Bureau of Standards (NBS)-traceable standard of ^{226}Ra sorbed on charcoal in a "cottage-cheese carton" is counted at least once a day to determine the counting system's efficiency. A container of unexposed charcoal is also counted each day to determine the background. The radon flux is calculated from the net counts, collector area, exposure time, and counting system efficiency. A detailed procedure for preparing and deploying the collectors and calculating the radon flux is presented in Appendix A.

This method of radon flux measurement involves two basic assumptions. First, it is assumed that the charcoal is 100% efficient in collecting radon. For short time periods (<36 hours) this assumption is considered valid (Hartley et. al 1983). The charcoal may not be 100% efficient, however, if longer exposure times are used. The main factor affecting the efficiency of charcoal for radon collection is temperature.

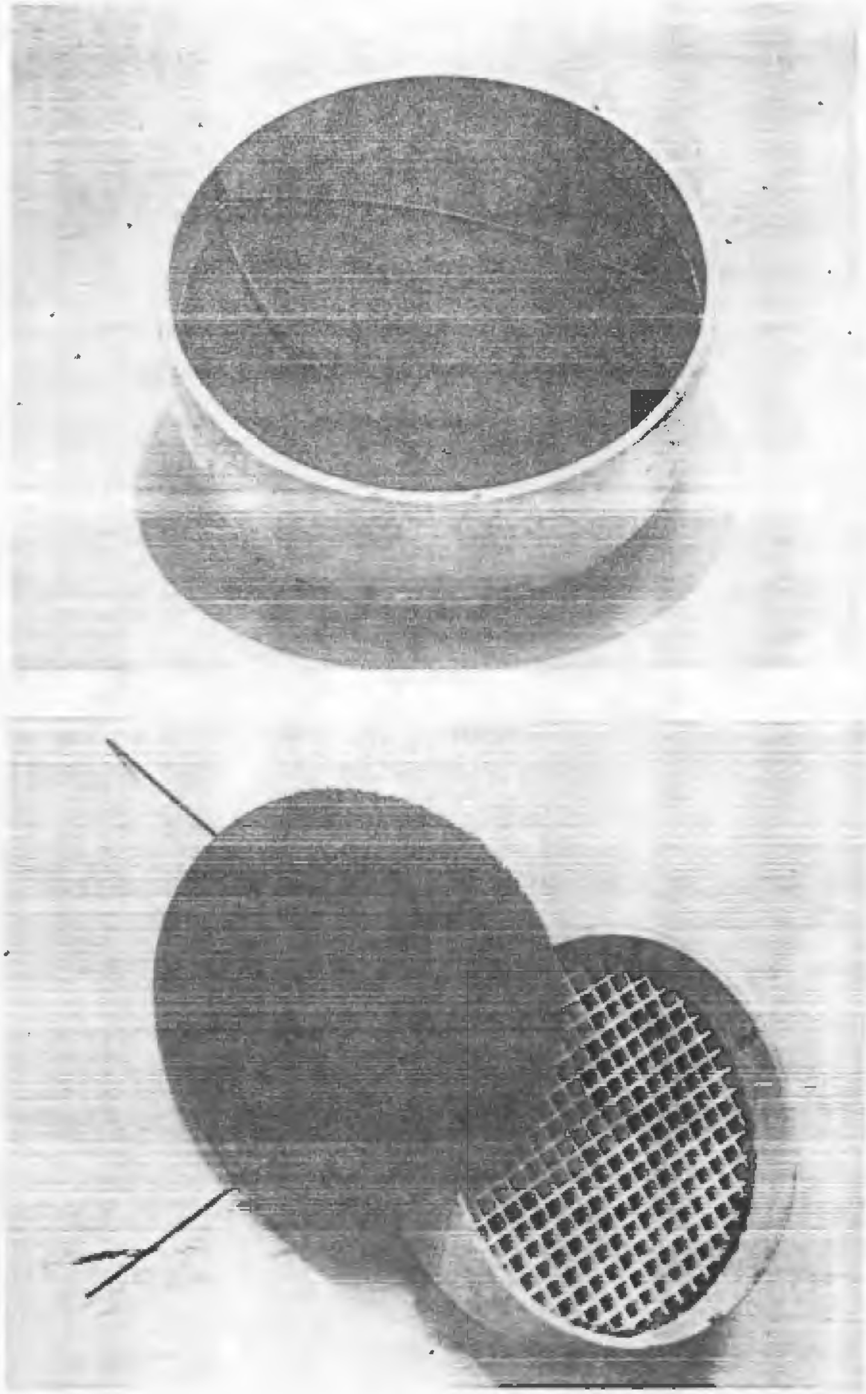

FIGURE 2. Components of Large-Area Radon Collector

Longer exposure times can be used in the winter than in the summer. Twenty-four hours is a conservative estimate of a valid exposure time for any time of year.

The second assumption is that the radon flux being measured is constant over the exposure period. Although it is known that this condition is rarely, if ever, met, the errors introduced are relatively small.

DETERMINING THE NUMBER OF LOCATIONS TO SAMPLE ON EACH PHOSPHOGYPSUM PILE

To estimate a statistically valid annual average radon flux for a phosphogypsum pile, the proper number of locations on the pile must be measured. The number of measurements needed to define the annual average flux depends on the homogeneity of the pile and the desired precision of the estimate. A homogenous pile requires fewer samples than a nonhomogenous pile. Standard statistical techniques (Holloway 1981) can be used to estimate the number of samples needed to estimate an average for a given error limit and uncertainty. The basic formula used to estimate the number of samples is:

$$\frac{\tau(n)\ s}{\sqrt{n}} < (\text{error})\bar{x} \tag{1}$$

where $\tau(n)$ is the students-τ distribution

s = measured standard deviation of the radon flux from the pile

$\bar{x}$ = measured mean of the radon flux from the pile

error = allowable error (expressed as a fraction)

n = number of samples.

This equation can be rearranged to give the error as a function of $\bar{x}$, s, n, and $\tau(n)$.

$$\text{error} \geqq \frac{\tau(n)\ s}{\bar{x}\ \sqrt{n}} \tag{2}$$

For sample numbers greater than 30, $\tau(n)$ can be assumed to be 1.7. However, for sample numbers less than 30 where the students-τ distribution is nonlinear the actual students-τ distribution should be used.

Equation 2 was used to estimate the errors in the estimate of the radon flux average for the Gardinier and Royster phosphogypsum piles. The Royster pile was divided into active and inactive regions for the analysis. A confidence interval of 90% was used. Results of this analysis are presented in Figure 3. From this figure, it can be seen that approximately 28 samples are needed for the Gardinier pile in order to have a 25% error in the estimate of the average radon flux. The Royster pile, on the other hand, would require 12 and 93 samples for the active and inactive portions of the piles, respectively. This same analysis can be easily performed for other confidence intervals by using the appropriate students-τ distribution. A larger confidence interval (i.e., α = 0.025, 95% confidence) would necessitate more samples, while a smaller confidence interval (i.e., α = 0.1, 80% confidence) would require fewer samples.

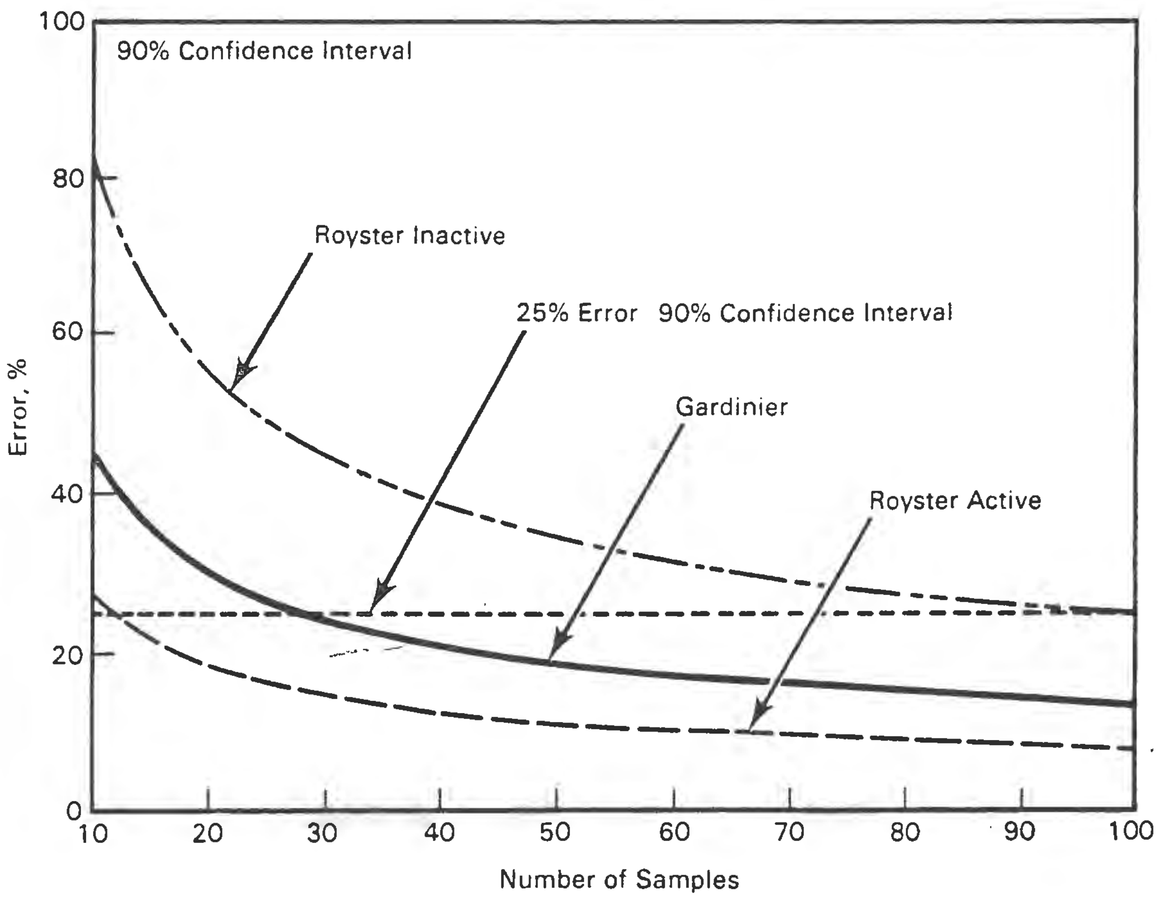

FIGURE 3. Error in Estimated Radon Flux Average for Gardinier and Royster Piles

APPENDIX A

PROCEDURE FOR MAKING RADON FLUX MEASUREMENTS USING LARGE-AREA ACTIVATED CHARCOAL CANISTER (LAACC)

INTRODUCTION

Each LAACC is constructed from a PVC end cap, fiberglass screen, and plastic grid and scrubber pads as shown in Figure A.1. The LAACC represents an improvement over the previous standard M1 charcoal canister in that it measures a much larger area. The radon collection mechanism, however, is the same; namely, sorption on activated charcoal. The amount of radon sorbed on the activated charcoal is quantified by gamma-ray spectroscopy of the charcoal using a NaI(Tl) crystal or germanium diode and multichannel analyser. Usually, the ^{214}Bi 609-keV peak is used to determine the radon activity, but many other ^{214}Bi and ^{214}Pb peaks could also be used. The radon flux is calculated from the radon activity using the area of the collector, time of measurement, and radon decay corrections.

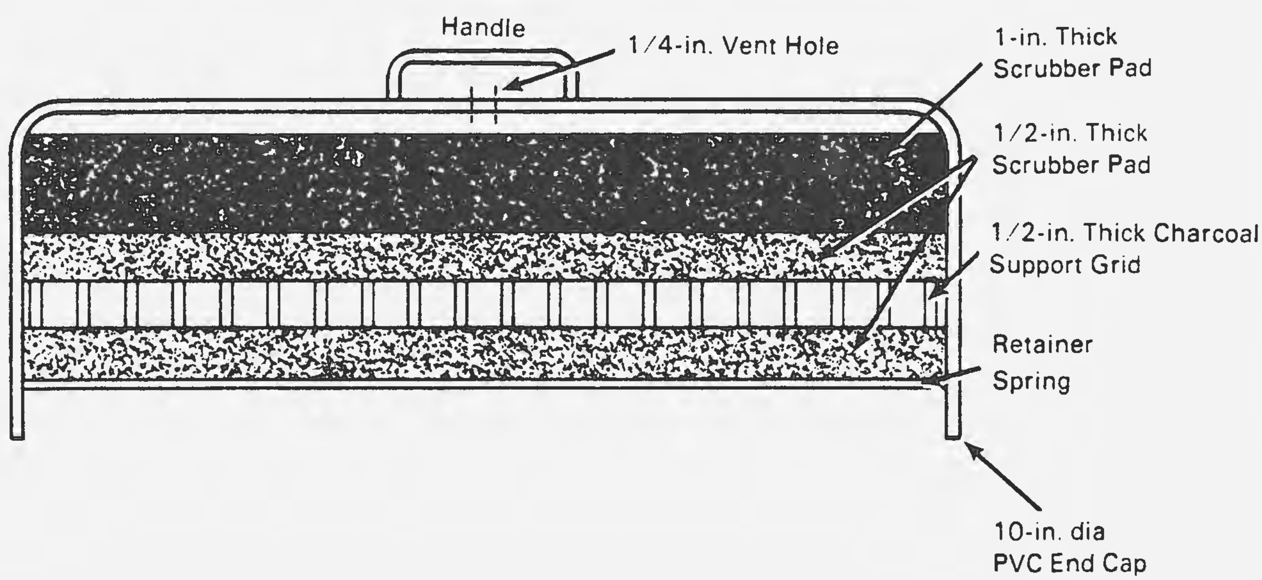

FIGURE A.1. Large-Area Radon Collector

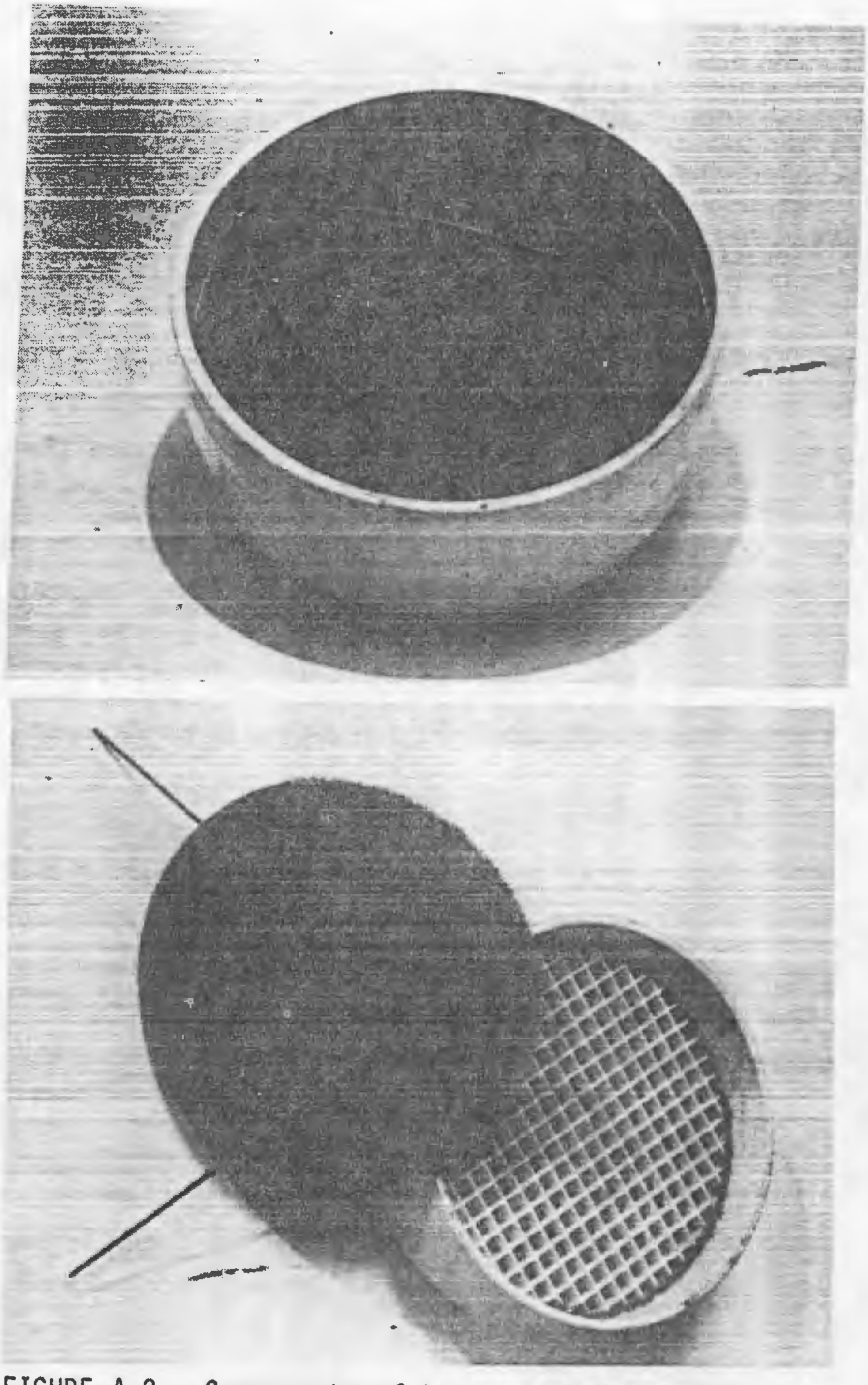

FIGURE A.2. Components of Large-Area Radon Collector

This appendix describes the proper techniques for making the radon flux measurements, including precautions on the proper times to make measurements and on handling of the charcoal before and after making the measurement.

LAACC DESCRIPTION

Figure A.2 shows an exploded view of the components of a LAACC. The LAACC constructed by PNL for the EPA consists of a 10-in. inside diameter (ID) PVC end cap with a 1/4-in. hole drilled in the center and a 5-1/4-in. handle, 1-1/2-in.-thick spacer pads, fiberglass screen, 1/2-in. plastic grid material, and a removable 1/2-in. scrub pad with fiberglass screen attached. The bottom pad and screen are held in the end cap by a piece of 3/32-in.-dia spring steel.

The 1/4-in. hole in the top of the end cap allows atmospheric pressure changes to be transmitted under the end cap and prevents pressure differentials between the inside and outside of the LAACC. Pressure differentials can have detrimental effects on measuring the radon flux by causing advective transport of the radon from the soil.

Activated Charcoal Preparation

The activated charcoal to be used for flux measurements should be thoroughly purged of any radon sorbed from atmospheric sources before being used the first time. This can be accomplished by heating the charcoal in an oven at 110°C for 24 hours. An oven with a circulating fan is preferable. The activated charcoal should then be cooled to room temperature in a place that is as free of radon as possible. Avoid storing the charcoal on or near obvious sources of radon (e.g., at the phosphate mill). After the charcoal is activated in the oven, it should be stored in airtight containers such as taped plastic bags or buckets with sealable lids.

Loading the LAACC

1. Turn the LAACC over on its handle and remove the retainer wire and bottom pad.

2. Pour ~400 mL (EPA "cottage-cheese carton" full) of activated charcoal in the center of the plastic grid. Distribute the charcoal evenly over the grid with your fingers or with a straight-edge.

3. Place pad, screen side toward the charcoal, on the grid.

4. Secure the pad in the LAACC by inserting the retainer wire in the notches on the inside of the LAACC.

5. If several hours will elapse between time of loading and time of deployment of the collectors, then the LAACCs should be placed in plastic bags and sealed with tape.

Making Radon Flux Measurements

1. Make sure the measurement location is fairly level and free from large rocks and vegetation.

2. Place the LAACC on the desired location by firmly rotating the edge of the end cap into the soil. Be careful not to push the lip of the end cap too far into the soil. There should be 1/4 to 1/2 in. of space between the surface being measured and the pad. If the surface to be measured is very hard, seal the edge of the LAACC using loose gypsum or soil.

3. Record the location, LAACC number, date, and time of deployment in a permanent logbook using ink. Do not use loose sheets of paper as they have a tendency to become lost.

4. Allow the LAACC to collect radon for ~24 hours.

5. Remove the LAACC from its measurement location and place in a plastic bag or unsealed in the vehicle if the unloading process is to take place within about an hour. Record the off date and time in the log book using ink.

6. Make gummed labels for each measurement that includes the location, LAACC number, and measurement start and stop dates and times.

7. Transport the LAACCs to a low-radon area for unloading. It is important to unload the LAACCs as soon as possible, especially in warm weather. Otherwise, the radon will begin to desorb from the charcoal to the atmosphere.

Unloading the LAACCs

The charcoal in the LAACCs must be transferred to a container before the quantity of radon on the charcoal can be analysed. The transfer process is described below.

1. Lay the LAACC upside down (on its handle) and remove the retainer wire. Save the wire for reuse.

2. Carefully remove the pad from the LAACC, making sure that any charcoal that clings to the screen is brushed back into the end cap or the funnel.

3. Dump the charcoal in the LAACC into a large bowl or pan. Then transfer the charcoal through a funnel into a "cottage-cheese carton" or other container. Use care to minimize charcoal loss. Place the lid on the "cottage-cheese carton" and seal with vinyl tape.

4. Place the appropriate gummed label on the lid of the "cottage-cheese carton" for identification.

5. Allow 4 hours for equilibration of radon and its daughters before counting.

Counting the Activated Charcoal

The system used to quantify the amount of radon adsorbed on the charcoal consists of a scintillation crystal (NaI) with high-voltage supply, amplifier, and scaler. A multichannel analyser, which would allow the counting system operator to see the peaks of interest and make necessary adjustments if the electronics are not stable, would also be very helpful. The ^{214}Bi 609-keV peak is recommended for use in quantifying the radon. The specifics of operating the counting equipment will be provided by EPA personnel.

To ensure high-quality radon flux data, certain quality assurance procedures must be followed. First, a standard, traceable to the National Bureau of Standards (NBS), must be counted on a daily basis to detect changes in counting system performance. The standard should be made of an NBS radium chloride solution sorbed onto activated charcoal in the same geometry that will be used for radon flux samples. The EPA will provide the standards for counting.

Secondly, a blank should be made of each batch of activated charcoal that is used. If the same batch of charcoal is used on different days, a new blank should be prepared for each day. If time is available, ~~the~~ blanks should be counted over a longer time period than the normal radon flux samples. This longer count time will improve the counting statistics for this low-level sample.

Thirdly, a randomly selected group of samples of 5% to 10% of the total should be recounted to check for leaking containers and reproducibility of counting technique. All counting data should be entered into a permanent notebook using ink.

Radon Flux Calculations

The radon flux is calculated from the net counts, collector area, exposure interval, detector efficiency, and relative counting times. The equation for calculating the flux is:

$$J = \frac{C\lambda^2}{K\ A\ E \left(1-e^{-\lambda t_1}\right)\left(e^{-\lambda(t_2-t_1)} - e^{-\lambda(t_3-t_1)}\right)}$$

where J = radon flux, pCi $m^{-2}s^{-1}$

C = net counts under ^{214}Bi 609-keV peak

λ = radon decay constant, 2.097 E-6/s

A = area of collector, m^2

E = efficiency of detector, c/d

K = conversion from d/s to pCi, 0.037 d/s/pCi

t_1 = exposure time, s

t_2 = time from start of measurement to start of counting, s

t_3 = time from start of measurement to end of counting, s.

The radon flux calculations can be greatly simplified by using a computer or programmable calculator. A program for the Hewlett Packard (HP) 41C programmable calculator is given in Table A.1.

TABLE A.1. Hewlett Packard (HP) 41C Program for Calculating Radon Flux[a]

```
01♦LBL "TIME2"
02 "INPUT SAMPLE NO"
03 AON
04 PROMPT
05 PRA
06 ADV
07 AOFF
08 "INPUT DAY1"
09 PROMPT
10 STO 01
11 "INPUT TIME1"
12 PROMPT
13 HR
14 STO 02
15 "INPUT DAY2"
16 PROMPT
17 STO 03
18 "INPUT TIME2"
19 PROMPT
20 HR
21 STO 04
22 ENTER↑
23 RCL 02
24 X>Y?
25 GTO 02
26 RCL 04
27 ENTER↑
28 RCL 02
29 -
30 3600
31 *
32 STO 05
33 RCL 03
34 ENTER↑
35 RCL 01
36 -
37 STO 06
38 86400
39 *
40 RCL 05
41 ÷
42 STO 06
43 GTO 04
44♦LBL 02
45 24
46 ENTER↑
47 RCL 02
48 -
49 RCL 04
50 +
51 3600
52 *
53 STO 08
54 RCL 03
55 ENTER↑
56 RCL 01
57 -
58 1
59 -
60 86400
61 *
62 RCL 08
63 +
64 STO 06
65♦LBL 04
66 "INPUT T1"
67 FIX 0
68 4
69 PROMPT
70 STO 11
71 INT
72 3600
73 *
74 STO 05
75 RCL 11
76 FRC
77 6000
78 *
79 ST+ 05
80 "T1= "
81 ARCL 05
82 PRA
83 "T2= "
84 ARCL 06
85 PRA
86 RCL 06
87 ENTER↑
88 600
89 +
90 STO 07
91 "T3= "
92 ARCL 07
93 PRA
94 XEQ "RADON"
95 END
```

```
01♦LBL "RADON"
02 2.097 E-6
03 STO 01
04 "INPUT COUNTS"
05 PROMPT
06 STO 04
07 RCL 01
08 X↑2
09 ENTER↑
10 RCL 04
11 *
12 STO 08
13 RCL 02
14 ENTER↑
15 .037
16 *
17 RCL 03
18 *
19 STO 09
20 RCL 05
21 ENTER↑
22 RCL 01
23 *
24 CHS
25 E↑X
26 1
27 -
28 CHS
29 RCL 09
30 *
31 STO 10
32 RCL 06
33 ENTER↑
34 RCL 05
35 -
36 RCL 01
37 *
38 CHS
39 E↑X
40 STO 11
41 RCL 07
42 ENTER↑
43 RCL 05
44 -
45 RCL 01
46 *
47 CHS
48 E↑X
49 RCL 11
50 -
51 CHS
52 STO 12
53 RCL 10
54 *
55 1/X
56 RCL 08
57 *
58 STO 13
59 ST+ 14
60 FIX 0
61 "NET COUNTS="
62 ARCL 04
63 PRA
64 FIX 1
65 "R FLUX= "
66 ARCL 13
67 "├ PCI/M2-S"
68 PRA
69 ADV
70 .END.
```

(a) The following information is provided for using the program:

- store collector area in register 02
- store detector efficiency in register 03
- execute time 2 program
- radon program is used as a subroutine
- day 1 is day measurement was started
- time 1 is time measurement was started (HH.MM)
- day 2 is day charcoal sample was counted
- time 2 is time charcoal sample was counted (HH.MM)
- T1 is exposure time of measurement (HH.MM)
- counts is net counts for ^{214}Bi 609-keV peak.

Radon -- A Perspective for the Layman

G. L. Gels

Back about 100 years ago when I was in high school, I vaguely remember memorizing the elements and their symbols for a chemistry exam. That was the first time I ever heard of radon, and until recently, for most people, it was the last. As I recall, radon was one of 92 elements that made up everything in the world. During high school chemistry class, the teacher (and the textbook) talked about a number of these elements and how they interacted with each other. Radon was never discussed.

If you were to dig out your old chemistry textbook and look up a periodic table of the elements, you would find radon in the lower right corner of the table in a column of elements called "noble gases." The lower part of the periodic table is full of strange elements that most people have never heard of. But if you look only at the column that radon is in, you see some elements that may ring a bell: there is helium (balloons), neon (signs), krypton (Superman?) and xenon. Radon is a member of this group and has similar properties. It is a noble (or inert) gas. That is, it just does not react chemically with other elements except under most unusual circumstances. This property makes it very difficult to control if you were to find it in your home in high concentrations.

Why would you want to control its concentration in your home? And how does it get into your home in the first place? And where does it come from? These are questions that thousands of people are asking themselves each day. I've been hearing them in increasing frequency over the past couple of years. It seems obvious that people are becoming concerned with the "problem" of radon in their homes recently as more and more has been written about it in the local and national press. I've been reading these articles also and usually I feel disappointed after reading them. Most of the time, I feel that the writer has either left out important facts, included "facts" that are not true or in some other way confused the issues and possibly raised unnecessary fears and concerns in the reader's mind. It was not until the other evening when my brother started asking me questions about radon after seeing a program on the subject on public television that I decided to try my hand at making sense of this complicated subject in terms that the layman could understand.

The "radon problem" is multifaceted. Some of the aspects of the problem are:

1) the noble gas (inert chemically) property;
2) the radioactive series decay effects;
3) the physical behavior of microscopic particles; and,
4) the health consequences involved.

This is a fairly impressive array of scientific-type problems likely to intimidate even the most concerned layman. You might be asking yourself, "Does anyone know everything about radon and its health effects?" The answer to that question is, "No." There are still a number of questions concerning the physical behavior of radon and its decay products as well as the health effects that result from breathing them that are still being debated in the scientific community. However, there are a lot of facts that everyone agrees upon and which should be understood by the public before they rush off to purchase some "radon removing" gadget that might not be effective or before they ignore possible health consequences of high radon concentrations in their homes. That is the purpose of this article.

**** Where does radon come from? ****

We've already mentioned that radon is a noble (or inert) gas. Where does it come from? How does it find its way into our homes? To answer those questions, we should start way back at the creation of the elements that make up our world. At the time matter as we know it was created, all 92 of the present elements (and perhaps many more) were present. Each of the 92 elements consisted of a number of isotopes. An isotope is possible because in an atom's nucleus there is always a number of protons (from 1 to 92, the number of protons defines which element is which) and a number of neutrons. For instance, carbon has six protons in its nucleus. One of its isotopes (the most common, carbon-12) has six neutrons. Another isotope of carbon, carbon-14 has six protons and eight neutrons. This isotope is radioactive and has a 5000 year half-life. It would have decayed away billions of years ago (actually, the carbon-14 that was created during the "big bang" has long since decayed), but this isotope is continually being replenished as a result of the interaction of radiation from outer space with stable nitrogen-14 in the earth's atmosphere. Any radioactive isotope with a half life less than about a billion years is long gone from the earth, unless it is being replenished like carbon-14. Radon has a half-life of 3.85 days. It is continually being replenished because it is a member of a radioactive series decay chain. At the head of this chain is uranium-238 with a half-life of 4.49 billion years. Every atom of radon that we see today began as an atom of U-238 billions of years ago. Since uranium-238 is found in almost all soils (to a greater or lesser degree), then radon is found in similar quantities in all soils. Each atom of U-238 will eventually decay into its "daughter product," the next member of the radioactive chain. Eventually, after enough years, radium-226 (one of the daughter products farther down the line) will decay and become an atom of radon-222. At this point, the atom which began as uranium is now a gas, radon, and has the potential to move through the soil like any other gas. Unlike most other gases, though, radon is radioactive and will itself undergo decay in a matter of days. When it does decay, its daughter products are all solids up to and including the final product of the chain, lead-206. So, if the radon does not diffuse out of the soil and into your house before it decays, it will never become a problem in the air you breathe. How far can radon diffuse in the soil around your house? The answer is anywhere from a few centimeters to many meters depending upon what kind of soil your house is built on. While scientists are able to predict which areas of the country are likely to have high or low concentrations of radon, they are still unable to determine exactly what causes a concentration to be high in one home and much less in the home next door. Obviously, one strategy to avoid radon in the air of your home is to prevent it from diffusing into your home in the first place, not exactly an easy task when you consider that radon is chemically inert and as a gas has the ability to diffuse through the smallest crack in your home's foundation.

**** Another radon pathway ****

There is another way that radon might enter your home, and that is through your water supply. Radon will not normally stay dissolved in water for very long if the water is exposed to the atmosphere, but those homes which use groundwater which is drawn from an aquifer passing through rock and soil rich in radium (such as granite or phosphate) may have a source of radon as well as a source of water coming into their homes. Drinking water with radon in it is not usually a problem, but when the radon is released to the air, for instance while taking a shower or using a dishwasher, the levels of radon in the air will increase. Most homes, particularly those with public water supplies, can safely ignore this as a potential source of radon in the air. However, if you use a well for your water supply and it is drilled in an area known to have high levels of radium in the soil, it might be a good idea to have your water tested also. Extra ventilation during times of high water usage might help alleviate the problem.

**** How does radon affect health? ****

Well, let's say that radon does find its way into your home. What happens then? For example, what would be the health consequences of breathing radon at the EPA-recommended remedial action level of 4 picocuries per liter? (A liter is approximately equal to a quart in volume and a picocurie is 2.2 radioactive decays per minute.) Surprisingly, the health consequences of breathing such a level <u>of radon</u> would be minimal. The reason is that radon itself does not contribute very much to the radiation dose to the bronchial area of the lungs, but the decay products (or "daughter products") of radon do. This is because, while radon is an inert gas and will not be trapped in the lungs, the daughter products of radon are solids which will have a tendency to "plate out" on the surfaces of the lung and remain there long enough to decay while still in the lung. The four immediate daughter products of radon (polonium-218, lead-214, bismuth-214 and polonium-214) have half-lives ranging from microseconds to about a half-hour. Two of the four decay by emission of an energetic alpha particle which concentrates a lot of ionization in a very small volume of tissue. These ionizations cause damage to the tissue, some of which is eventually repaired. Some of the damage, however, is not repaired and it is theorized that this radiation-caused damage in some cases may lead to lung cancer. The daughter products of radon may also plate out on other surfaces such as dust particles in the air or solid surfaces in the room.

**** Daughter product equilibrium. ****

The term "percent equilibrium" is used to describe how many of the daughter products of radon are available in the air (that is, how many are potentially respirable) compared to the activity of radon in the air. If half of the daughter products have plated out on solid surfaces or have in some other way been removed from the air (for instance, by use of an electronic air cleaner) then the daughters are said to be in 50% equilibrium with radon. In general, the more radon daughter products that can be removed from a given volume of air, the safer that air will be to breathe. Of course, as long as radon is present in the air, daughter products will continue to be produced, so any scheme to "control" the daughter products without reducing the concentration of radon will have to be continuous or else daughter product concentrations will return to previous levels within a matter of a couple of hours.

**** The "Working Level". ****

There is another term used to describe radon daughter product concentrations -- the "Working Level," or WL. The definition of the WL has changed somewhat over the years, but it was adopted initially to describe the radon daughter product concentrations that uranium miners were exposed to. It is important to always remember that the Working Level applies only to the daughter products of radon, not to radon itself. One Working Level can be defined as that concentration of radon daughter products that are in 100% equilibrium with 100 picocuries/liter of radon. Since one seldom finds 100% equilibrium conditions, even in the laboratory, it is usually assumed that in the home, the radon daughter products are in 50% equilibrium. That means that it would take twice as much radon (i.e., 200 picocuries/liter) to produce one Working Level of radon daughter products. Thus, at an assumed 50% equilibrium, the EPA-recommended action level of .02 WL of radon daughter products would convert to 4 picocuries/liter of radon. Another way to say this is that it would take 4 picocuries/liter of radon to produce .02 WL of radon daughter products if half the daughter products were removed before a person breathed the air. If, by some control strategy, you were able to reduce the radon daughter products to 25% of equilibrium, 8 picocuries/liter of radon would be necessary before you would reach the "action level" of .02 WL.

With this background, let's go back and ask again some of the questions that were posed in the beginning of this article. How does radon get into your home?

**** How does radon get in your home? And why? ****

When the windows of your house are open, any radon diffusing into it from the soil around it is quickly diluted by the air entering your house from outside. The outside air is a huge reservoir into which the radon mixes quickly. Outdoor concentrations of radon are generally much less than indoor because of this mixing. Radon is only produced in the soil, and will accumulate to higher concentrations outdoors near the ground only under stagnant meteorological conditions; that is when there is an inversion and the winds are relatively calm. However, when your house is closed up tight two things happen which tend to increase the concentration of radon indoors. First, it is obvious that any radon which diffuses into your home from the soil is much less likely to find its way outdoors. Second, the atmospheric pressure within your home will probably be just slightly less than that outdoors. The easiest way to understand this is to compare the wind blowing over and around your home with the air flowing over an airplane wing. As air flows over the top of an airplane wing, the pressure on the top part of the wing is reduced, giving the plane its "lift." As the air flows past your closed home, its pressure is slightly reduced, which in turn tends to reduce the pressure within the home. In addition, any combustion-type heater within the home will tend to decrease the pressure within as combustion products are vented outside. The net effect of this decrease in air pressure within the home is that the soil gas which is rich in radon will diffuse much more readily into an area of lower pressure. So, when the house is closed, more radon is likely to diffuse into the house and less is likely to escape. [It is sometimes mistakenly assumed that since radon results from decay of radium found in the soil, that there is a pressurized source of radon pushing it out of the soil into your home. This is not the case. The equilibrium volume of radon produced in many cubic meters of soil around your home is less than a cubic centimeter, not enough to affect the pressure of the soil gas in any way.] In recent years homes have been made more "tight" thanks to modern technology and construction techniques, and this has only exacerbated the radon problem in some homes.

**** Some ways to keep radon out. ****

In the light of the above, some of the ways to keep radon out of your home become more understandable. Obviously, sealing any cracks in the foundation and gaps around sumps or places where pipes or conduit enter through the foundation can only help. Ventilation of the crawl space in those homes that have one is a relatively inexpensive way to address the problem. One way (perhaps not the most practical), would be to somehow keep the air pressure in your home slightly higher than that outside. Another way would be to ventilate your basement. In the winter time, since you have paid to heat this air, it might make good economic sense to include some sort of heat exchange scheme in your ventilation system to keep your utility bills within reason, although the initial cost of adding a heat exchanger might be rather high. Another method that should be considered, particularly if you are able to address the problem during the construction phase of your home, is to backfill around the home's foundation with coarse gravel and ventilate this "buffer zone" with outside air. The advantage of using a strategy designed to keep radon out of the home is that, if you are successful, you've broken the chain of radioactive decay and you no longer have to worry about dealing with the daughter products of radon.

Since radon itself delivers only a small percentage of the total lung dose when a mixture of it and its daughter products are present, an alternate strategy is to reduce the number of daughter products that are present in the air of your home. How might you do this? To get an idea of how this problem might be attacked, let's look at what happens when an atom of radon decays in the air of your home.

**** When radon decays. ****

On an atomic scale, the atom of radon is bouncing around with many billions of atoms of oxygen and nitrogen and other gases along with many thousands of tiny dust particles per cubic meter. When the radon atom decays by emission of an alpha particle (a tightly-bound clump of 2 protons and 2 neutrons) from its nucleus, two things occur immediately: 1) since two protons have been removed from the nucleus, it is no longer an atom of the element radon -- it is now polonium, which is not a gas, but a solid; and 2) as the alpha particle with its charge of +2 (due to the two protons) rips through the cloud of electrons surrounding this new atom of polonium, a few of these electrons are knocked out of their orbits around the nucleus, leaving the atom as a whole with a net deficiency of electrons (in other words, a net positive charge). In a relatively short period of time this deficiency will be filled, but until it is, this positively-charged atom will be attracted to anything with a net negative charge, like one of those ever-present dust particles or the screen of your TV set. Within the next half-hour or so, this atom will decay four more times. The object of any "daughter product control strategy" is to make certain that this atom (and others like it) are not in your lungs when these decays occur. There is very little potential health effect from exposure to these daughter products when they are outside of your body. So, the question becomes, "How do we keep these atoms out of our lungs?"

**** Radon daughter product removal. ****

One strategy would be to filter them. Since a percentage of the radon daughter products will attach themselves to the dust in the air, filtering this air to remove the dust should be effective based on the fraction of daughters attached to filterable particles and the efficiency of the filter. If an electrostatic filter is used along with a pre-filter, those unattached atoms still carrying a charge will also be collected. It should be emphasized here that any of these strategies designed to remove the daughter products of radon will do nothing to remove the (inert) radon gas itself. Therefore, if the removal procedure is discontinued for very many minutes, the daughter product concentration will quickly return to previous levels. After about an hour, the daughter product concentration could rise from zero to about 75% of maximum.

It has been suggested that the addition of charged ions into the room air may help reduce the number of radon daughter products entering the lungs, perhaps by increasing the number of dust particles that are charged and thus creating a place for the daughters to become attached and thence to be filtered or to plate out on some surface other than the lung. Air movement alone (such as with a ceiling fan) has been shown to be somewhat effective in removing daughter products, presumably because of the increase in the probability that the daughter product atom (whether charged or neutral) will encounter a surface on which to "plate out."

**** Deciding what to do. ****

Quite a few possible strategies for reduction of dose due to radon daughter products have been proposed, and a number have been tested under laboratory conditions. There does not seem to be a consensus at this time about which of the various proposed methods would be best for the average home. One of the reasons for this is that it is not possible to measure the dose to an actual lung while using the various strategies. The best that can be done is to filter a portion of the air and measure the particle sizes and daughter product activity associated with each particle size. The dose to the lung can be estimated then using a lung model, but there is not a consensus among scientists on which lung model is the best to use. Obviously, certain strategies are more appropriate for one homeowner than another. If your home does not have a central air heating system, installation of a number of ceiling fans would be a lot easier than construction of the necessary ductwork and installation of an electrostatic filter. Several booklets are available free of charge from the U. S. Environmental Protection Agency, through the state of Ohio. They are, "A Citizen's Guide to Radon," and "Radon Reduction Methods: A Homeowner's Guide," and they can be obtained by calling the Ohio Department of Health's "Radon Hotline," 1-(800)-523-4439 or 1-614-644-2727. State EPA and/or health agencies may be able to offer advice also for homeowners within their state. It would be good advice for any homeowner to not purchase any device for radon reduction unless it has been determined by actual measurements that a problem exists in their home, and then to be extremely suspicious of marketing claims that sound "too good," and don't explain how the device works in simple enough terms for the layman to understand.

**** Testing for radon. One method. ****

How should you go about getting your home tested for radon? If you do a little investigating, you will find that there are quite a few companies out there that would like to help you (for a price) determine the radon concentration in your home. A list of state-approved radon companies can be obtained by calling the Radon Hotline, 1-800-523-4439. You can even buy do-it-yourself radon test kits in department stores and convenience stores. There are different methods used to test for radon, and you should be aware of at least some of the advantages and disadvantages of the more widely-used methods. For widespread use by the homeowner, there are two methods that are relatively inexpensive and simple to use and do not require a trained professional with expensive equipment to come to your home. One is the charcoal canister or bag. Activated charcoal has the ability to trap (adsorb) atoms of radon. In part because of the relatively short half-life of radon (3.85 days), this technique follows a law of diminishing returns and a week is about as long as these detectors can be left exposed in the home. The canister or bag is then re-sealed and returned to the laboratory where gamma-rays being emitted by one of the radon daughters (bismuth-214) are counted. The number of gamma rays counted can then be related by a mathematical formula to the concentration of radon that the charcoal was exposed to. Some of the possible drawbacks of this method are the short deployment time (no more than a week), and interference with the radon adsorption due to high levels of humidity in the air. Also, the canister must be returned to the laboratory promptly, because the sensitivity of the measurement is directly related to the amount of radon in the charcoal <u>at the time it is counted</u>, and the radon is decaying (by a factor of 2) every 3.85 days.

**** Another "do-it-yourself" testing method. ****

Another method available by mail to the homeowner is an alpha track-etch technique. Instead of charcoal, the detector in this technique is a small piece of plastic. It is not an ordinary piece of plastic, however. It is capable of recording the tracks made by alpha particles as they penetrate into it. These tracks are recorded permanently, so there is no need to limit the amount of time this detector is exposed. Typical deployment times range from a month to a year. The detector is mounted in a container with a filter over its opening so that radon can easily diffuse into it, but the particulate daughters of radon are excluded. Therefore, it is a radon detector, not a radon daughter product detector. Upon return to the laboratory, the detector is treated chemically to make the alpha tracks visible for counting under a microscope. The number of tracks counted per square millimeter is directly related to the average radon concentration the detector was exposed to.

**** Factors that influence the test. ****

When testing your home with either of these methods, it is important to be certain that the home is "closed" as much as possible during the period of testing. The resulting measured concentration will then be a "worst case" concentration, since times when there is increased ventilation with the outdoors will decrease the average indoor radon concentration. This should also be a factor as you decide what is the magnitude of the radon problem in your home. Another decision that must be made is the location of the detector(s) for the test. Basements usually have the highest levels of radon, but the lowest occupancy factor. Central forced-air heating and air-conditioning would tend to mix the basement air more with the rest of the air in the house than would hot water heat using radiators. Therefore, perhaps a homeowner with a hot water heating system who seldom uses his basement would prefer to place a single detector on the first floor of his home to get a number representative of the conditions his family was usually exposed to. A better strategy would be to get two or three detectors and deploy one in the basement to determine "worst case" concentrations, one on the first floor and one on the second floor to determine more realistic conditions.

**** Use an "approved" detector. ****

Whatever detector you decide to use, make certain that the detector that is being offered to you has passed the USEPA Radon Measurement Proficiency Test. This is a test that is given quarterly by the USEPA in which detectors are supplied to the USEPA by the various vendors of radon detection services. The detectors are exposed in a calibrated radon chamber by the government and returned to the vendors for analysis. If the vendor is able to measure the radon concentration to the prescribed degree of accuracy, his detector will be listed among the "approved" detectors on a list available to the public from the USEPA. If you are considering determining the radon concentration in your home, one of the first things you should do is to determine whether the vendor you are planning to use has taken and passed the Radon Measurement Proficiency Test within the past year.

**** The magnitude of the problem. ****

What are the health effects of breathing air with elevated levels of radon in it? Since radon is produced in the soil just about everywhere, man has been exposed to it in some degree ever since he has been on this planet. Estimates vary, but many scientists are saying that as many as 20,000 cancer deaths per year in this country can be attributed to irradiation of the lung by the alpha particles from radon and radon daughter products. It has also been estimated that 10%

to 20% of the homes in the country may contain radon concentrations at or above the EPA-recommended action level. Whether or not you agree with the above estimates, it seems obvious that the radon problem is not trivial when compared with other potential risks to our health. As with any potential health risk, the state may be there to assist you, but the primary responsibility for your health and that of your family rests with you, the individual. Getting correct information about the risk and possible options for reducing that risk is the first step in fulfilling that responsibility. Hopefully, this article will help you understand better some of the things you've been reading and hearing about radon and its daughter products.

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606-282-7868

10-11-91

Rob -

I just came across this article. It supports some of the conclusions, particularly in the third paragraph, in the "Indoor Radon" write-up that I did.

Also, the uranium soil concentration results will provide a basis for comparison for the 10 soil samples being analyzed at the Montgomery, AL lab. (When are those results expected?)

Jerry

c: Art Ball

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9-8-91

Rob:

Here are the Bluewater data. If you want to vary the format, give me a call – I can probably tell you what to do over the phone.

Hey – keep Nov 29 open. I've heard a rumor that wedding bells might be ringing on that date. I understand that the decision on best man has come down to a contest between you and Raphael (if he's still alive).

Good luck Oilers – except on 10/27.

Jerry

WESTON
MANAGERS DESIGNERS/CONSULTANTS

SHEET 1 of ____

CLIENT/SUBJECT U.S. EPA / ERT, Bluewater Uranium W.O. NO. 4547

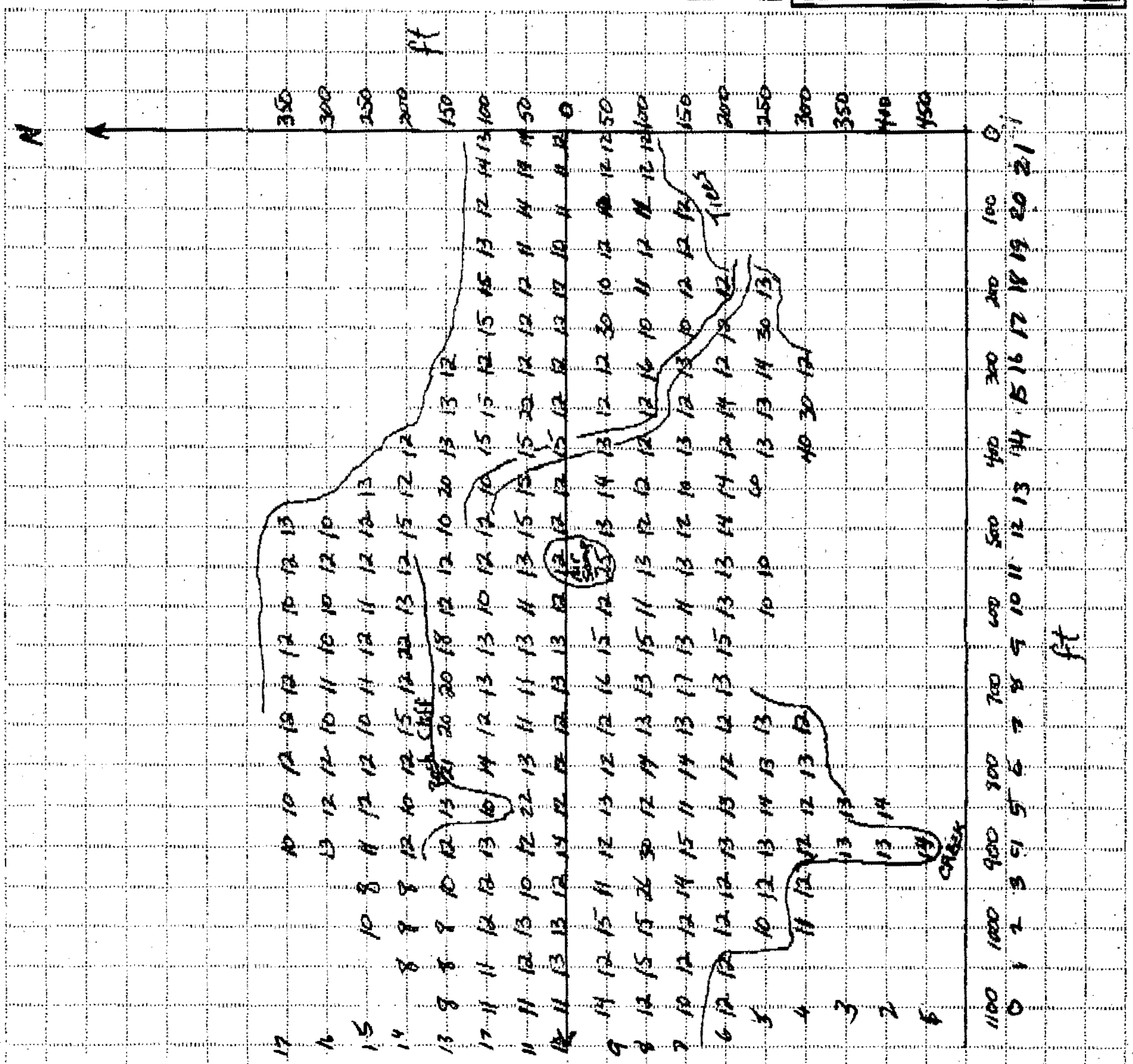
TASK DESCRIPTION Gamma Survey, 50' x 50' Grid, 1m height TASK NO. ____

PREPARED BY G.L. Gels DEPT REAC DATE 11/23-24/92

MATH CHECK BY ____ DEPT ____ DATE ____

METHOD REV. BY ____ DEPT ____ DATE ____

APPROVED BY ____ DEPT ____ DATE ____



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To Rob Bernstein	From Jerry Gels
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6/12/91

ATTACHMENT

PROPOSED SOIL SAMPLING LOCATIONS, DEPTHS, AND REQUEST FOR ANALYSES

Boring No.	Approx. Boring Depth	Sample Depth Interval	Sample Type	QA/QC Sample	PCB Anal.	VOC Anal.	Anticipated Sampling Date (1)	Sampling Rationale
CSB-09	30.0	0.0 - 0.5	Boring	Dup (2)	X (3)		7-8-91	C (4)
		2.0 - 2.5	Boring			X	7-8-91	H (5)
		5.0 - 5.5	Boring		X	X	7-8-91	C, H
		10.0 - 10.5	Boring		X		7-8-91	C
		15.0 - 15.5	Boring		X		7-8-91	C
		20.0 - 20.5	Boring		X		7-8-91	C
		25.0 - 25.5	Boring		X		7-8-91	C
		29.5 - 30.0	Boring		X		7-8-91	C
CSB-13[8]	19.0	0.0 - 0.5	Boring	Dup	X		7-9-91	E (6)
		5.0 - 5.5	Boring		X		7-9-91	E
		10.0 - 10.5	Boring	Lab QC (7)	X		7-9-91	E
		15.0 - 15.5	Boring		X		7-9-91	E
		18.5 - 19.0	Boring		X		7-9-91	E
		21.0 - 21.5	Bedrock		X		7-9-91	G (8)
		23.5 - 24.0	Bedrock		YY (9)		7-9-91	G
CSB-26	5.0	2.0 - 2.5	Boring			X	7-10-91	H
		4.5 - 5.0	Boring			X	7-10-91	H
CSB-27	5.0	2.0 - 2.5	Boring	Dup		X	7-10-91	H
		4.5 - 5.0	Boring			X	7-10-91	H
CSB-28	5.0	2.0 - 2.5	Boring			X	7-10-91	H
		4.5 - 5.0	Boring			X	7-10-91	H
CSB-29	5.0	2.0 - 2.5	Boring	Dup		X	7-10-91	H
		4.5 - 5.0	Boring			X	7-10-91	H
CSB-30	5.0	2.0 - 2.5	Boring	Dup		X	7-10-91	H
		4.5 - 5.0	Boring	Lab QC		X	7-10-91	H
CSB-31	5.0	2.0 - 2.5	Boring			X	7-11-91	H
		4.5 - 5.0	Boring			X	7-11-91	H
CSB-32	5.0	2.0 - 2.5	Boring			X	7-11-91	H
		4.5 - 5.0	Boring			X	7-11-91	H
New B-71	20.0		Boring				7-11-91	
New B-72	20.0		Boring				7-12-91	